Question			Answer	Marks	Guidance
1	(a)		**Kinetic** energy is conserved (when molecule collides) / collision is **elastic** (so velocity after collision is –*v*) Momentum change = $mv - [-mv]$ $= 2mv$	 M1 A1 A0	**Note: Kinetic** and **elastic,** wherever used, to be spelled correctly **Allow**: *m[v-(-v)] or –mv – mv* **Allow**: A1 mark if M1 mark has been lost for incorrect spelling
	(b)		Increase in temperature causes an increase in velocity / speed (of molecules) Collisions are more frequent (AW) Greater (rate of) change in momentum (in each collision with the surface) Hence force increases	B1 B1 B1 A0	**Note:** No credit for references to pressure [NAQ]
	(c)	(i)	$\frac{p_2}{T_2} = \frac{p_1}{T_1}$ $p_2 = \frac{2.2\times10^5}{(273+18)}\times(273+54)$ $p_2 = 2.5\times10^5$ (Pa)	 C1 A1	 **Note:** Mark is for substitution; any subject No marks if temperatures are not converted to kelvin Answer to 3 sf is 2.47×10^5 (Pa)
		(ii)	$\text{Original area} = \frac{W}{p_1} = \frac{1200\times9.8}{2.2\times10^5}$ $(= 5.35\times10^{-2})$ (m^2) $\text{Final area} = \frac{W}{p_2} = \frac{1200\times9.8}{2.47\times10^5}$ $(= 4.77\times10^{-2})$ (m^2) $\text{Change in area} = (5.35 - 4.77)\times10^{-2} = 5.8\times10^{-3}$ (m^2)	C1 C1 A1	 Possible **ecf** from **(c)(i)** **Allow:** Full credit if 2 sf values are used eg 6.4×10^{-3} (m²) using $p_2 = 2.5 \times 10^5$
			Total	**10**	

Question			Answer		Marks	Guidance
2	**(a)**	**(i)**	For a <u>fixed / constant mass</u> of gas at constant temperature Pressure is inversely proportional to volume / pressure x volume = constant		B1 B1	
		(ii)	Axes labelled p and $1/V$ OR V and $1/p$		B1	**No ecf from a(i)** **Note:** Only one tick
	(b)	**(i)1**	$pV = nRT$ $n = \frac{pV}{RT} = \frac{1.2 \times 10^7 \times 0.05}{8.31 \times (273 + 21)}$ $n = 250$		 C1 A1	**Allow:** use of $pV = NkT$ leading to $N = 1.48 \text{x} 10^{26}$ (C1) and $n = N/N_A$ giving $n = 250$ (A1) Mark is for substitution; any subject. No credit if 21ºC is used giving $n = 3438$
		(i)2	mass = n x 0.029 = 246 x 0.029 = 7.1 kg	mass = n x 0.029 = 250 x 0.029 = 7.3 kg	A1	Possible **ecf** from **(b)(i)1** Allow ecf if n = 3438 leads to mass = 99.7 kg

Question			Answer	Marks	Guidance
2	(b)	(ii)	$n_{air\ added} = \frac{pV}{RT} = \frac{1.0\times10^5 \times 1.5}{8.31\times(273+21)}$ $n_{air\ added} = 61.4$ $n_{total} = n_{initial} + n_{air\ added} = 246 + 61.4 \quad (= 307)$ $p_{final} = n_{total}\left(\frac{RT}{V}\right) = 307\times\left(\frac{8.31\times(273+21)}{0.050}\right)$ $p_{final} = 1.5\times10^7 \quad (\text{Pa})$	 C1 C1 C1 A1	Possible **ecf** from **(b)(i)1** or **2** **Allow** follow through for incorrect $n_{air\ added}$ value Using n =250 from **b(i)1** leads to $n_{total} = 250 + 61.4 \quad (= 311)$ Use of T = 21ºC or V =1.55 is wrong physics so can not score last two marks **ALTERNATIVE METHOD** Calculates pressure of air pumped in if it were to occupy a volume equal to cylinder $p_2 = \frac{1\times10^5\times1.5}{0.05}$ (C1) $p_2 = 3.0\times10^6$ (C1) When added to air already in cylinder $p_{final} = p_{original} + p_2$ $p_{final} = 1.2\times10^7 + 3.0\times10^6$ (C1) $p_{final} = 1.5\times10^7$ (Pa) (A1) **SPECIAL CASES** Using alternative method but with final volume taken as 1.5 m³ p_2 = 4.0 x 10^5 (Pa) and final pressure is 5.0 x 10^5 (Pa) Scores 2 marks . No credit if final volume taken as 1.55 m³
			Total	**10**	

Question			Answer	Marks	Guidance
3	(a)	(i)	Energy required to raise the temperature of a unit mass of a substance by unit temperature rise.	B1	**Allow:** $c = \dfrac{Q}{m\Delta\theta}$ with all symbols defined.
		(ii)	LH of fusion is energy needed to change (a substance) from <u>solid to liquid</u> LH of vaporisation is energy needed to change (a substance) from <u>liquid to gas/vapour</u>	 B1	Allow: a single reference to energy (either statement acceptable)
	(b)	(i)	**A to B**: KE of molecules <u>increases</u> <u>AND</u> PE of molecules (small) <u>increases</u> **B to C**: KE of molecules remain constant <u>AND</u> PE of molecules <u>increases</u>	B1 B1	
		(ii)	c_{solid} is **less than** c_{liquid} Correct reason **Eg** gradient for solid is greater than gradient for liquid AND gradient is inversely proportional to specific heat capacity (AW}	B1 B1	
	(c)	(i)	<u>In one second</u> volume flowing through = $(3.6 \times 10^{-3} /60)$ = 6.0×10^{-5} mass flowing through = $6.0 \times 10^{-5} \times 1000$ = (6.0×10^{-2}) Energy gained by water $E = mc\,\Delta\theta = 0.060 \times 4200 \times (36.7 - 17.4)$ (= 4864) Power of heater = E / t = 4864 /1 Power of heater = 4.9×10^{3} ≈ 5 kW	 C1 C1 C1 A1 A0	**Alternative** <u>In one minute</u> volume flowing through = 3.6×10^{-3} mass flowing through = 3.6 (C1) Energy gained $E = mc\,\Delta\theta = 3.6 \times 4200 \times (36.7 - 17.4)$ (C1) (= 2.92×10^{5} J) Power = E / t = $2.92 \times 10^{5} /60$ (C1) Power of heater = 4.9×10^{3} (A1) ≈ 5 kW (A0)
		(ii)	EITHER rate of flow of water changes **because** water pressure changes OR Inlet temperature changes **because** ambient temperature changes	 M1 A1	
			Total	**12**	

Question			Answer	Marks	Guidance
4	(a)		Gas molecules move in **random / erratic / haphazard** motion (AW) :	B1	**Use tick or cross on Scoris** ✐ **random / erratic / haphazard** must be spelled correctly to score the mark.
	(b)	(i)	constant temperature	B1	
		(ii)	$P_1V_1 = P_2V_2$ $350 \times 120 \times (A) = P_2 \times 55 \times (A)$ $P_2 = \frac{350 \times 120}{55}$ = 760 (kPa)	C1 A1	**Note:** Answer to 3 sf is 764 (kPa) **Note**: 7.6×10^5 (kPa) scores 1 mark
		(iii)	When a molecule collides with the (moving) piston it rebounds with higher speed / ke / momentum (Mean) kinetic energy of molecules is <u>proportional / ∝</u> to (Kelvin) temperature	B1 B1	Must refer to collisions with piston or rebounds from piston not collisions within gas molecules. Allow: $E_k = 3kT/2$ without definition of terms.
			Total	**6**	

5	Expected Answers	Mark	Additional guidance
(a)(i)	Latent heat of <u>fusion</u>.	B1	QWC fusion spelled correctly ignore any reference to specific.
(a)(ii)	Latent heat of <u>vaporisation</u>.	B1	QWC Vaporisation spelled correctly. **Accept** vaporization but not vapourisation.
(b)(i)	E = $mc\Delta\theta$ used correctly e.g. 0.8 x 4200 x 82 = 2.8×10^5 (J) (275520)	C1 A1	0.8 x 4200 x (82+273) scores zero
(b)(ii)	Any two from: Some heat/energy used to heat kettle Some heat/energy lost to surroundings/air/environment. Some heat/energy used to boil water before kettle switches off	B1 B1	Do **not allow** "some heat lost" i.e. they must state where/how Do **not allow** "kettle if not 100% efficient". Do not allow "energy lost as sound/light"
(b)(iii)	1 kWh = 1000 x 3600 = 3.6×10^6 J Wastage per year = (2.8×10^5 x 365) / 3.6×10^6 = 28 kWh (27.9)	C1 A1	**Allow** 1 mark for energy lost per year = 1.02×10^8 <u>Joules</u> Allow ecf from (b)(i)
	Total	**8**	