Marking Scheme

#1

Question	Marking details	Marks available					
		AO1	AO2	AO3	Total	Maths	Prac
	Indicative content **Heat** • No heat flow in or out of system as a whole • flows from A to B • flow rate decreases • eventually no flow **or** flow rate approaches zero **Internal energy** • A's decreases, B's increases • Rates of decrease or increase eventually approach zero. **Temperature** • A's decreases, B's increases • Temps of A and B approach [accept *reach*] a common value. **Motion of atoms** • Atoms are *vibrating*. • Motion correctly associated with temperature. Accept with internal energy.	6			6		
	5-6 marks Comprehensive account with all 4 areas covered i.e. heat, internal energy, temperature and motion of atoms. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive account of 2 or 3 areas i.e. heat, internal energy, temperature and motion of atoms or limited attempt of all 4. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Comprehensive account of 1 area i.e. heat, internal energy, temperature and motion of atoms or limited attempt of 2 or 3 areas. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** No attempt made or no response worthy of credit.						
	Question total	**6**	**0**	**0**	**6**	**0**	**0**

#2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			Energy [entering system] [1] by virtue of a temperature difference [or equivalent] [1]	2			2		
	(b)	(i)		Correct substitutions (ignoring power of 10) into $W = p\Delta V$ [1] W = 1.20 k[J] [1]	1	1		2		
		(ii)		**Indicative content:** **AB** Gas does work [or W positive] **and** internal energy rises [or ΔU positive] since temp rises [as gas expands at constant pressure]. So heat flows in [or Q positive] **BC** Gas has work done on it [or W negative]. No change in internal energy [or ΔU =0] so heat out [or Q negative] **CA** No work [or W = 0] but internal energy falls [or ΔU negative] so heat out [or Q negative] **ABCA** Net work done on gas [or W negative], no change in internal energy [or ΔU =0] so heat out [or Q negative] **5-6 marks** They have considered Q, W and ΔU well for all stages. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** They have considered 2 of Q, W and ΔU well for all stages. Or they have attempted to consider Q, W and ΔU for most stages. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** They have considered Q, W and ΔU well for all stages. Or they have attempted to consider 2 of Q, W and ΔU for most stages. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** No attempt made or no response worthy of credit.	6			6		
				Question 7 total	**9**	**1**	**0**	**10**	**0**	**0**

#3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)			Substitution i.e. $\rho = \frac{3(2.20 \times 10^{-18})^2}{8\pi(6.67 \times 10^{-11})}$ [1] $\rho = 8.66 \times 10^{-27}$ kg m^{-3} **(unit mark)** [1]	1	1		2	2	
	(b)			Increase in distance = $(2 \times 10^9 \times 365 \times 24 \times 3\,600 \times 2.2 \times 10^{-18})R$ $(= 0.14R)$ [1] R increased by 14 % [1] Nearly 15 %, justified [1] **Alternative:** $D \alpha \frac{1}{H_0}$ or $D = \frac{k}{H_0}$ [1] Appropriate algebra e.g. $D_1 = \frac{k}{1.44 \times 10^{10}}$ [years] and $D_2 = \frac{k}{2 \times 10^9 \times 1.44 \times 10^{10}}$ and/or $k = \frac{D_2}{D_1} = \frac{1.64}{1.44}$ [= 1.14] [1] Hence k approx. = 14 % shown (approx. 15 %) [1]			3	3	2	
	(c)	(i)		$\frac{\Delta\lambda}{410}$ calculated or shown: i.e. $\frac{65}{410}$ or 0.16 seen [1] v calculated = $0.16 \times 3 \times 10^8 = 4.8 \times 10^7$ [m s^{-1}] [1]		2		2	2	
		(ii)		Substitution and re-arrangement: Distance = $\frac{4.8 \times 10^7}{2.2 \times 10^{-18}}$ **(ecf** on v) [1] Distance = 2.18×10^{25} [m] [1]		2		2	2	
		(iii)		Use of $E_k = \frac{3}{2}kT$ $E_k = 1.47 \times 10^{-19}$ [J] [1] = 0.9[2 eV] [1]		2		2	1	
				Question total	**1**	**7**	**3**	**11**	**9**	**0**

#4

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*	(i)		ρ correctly calculated ignoring sig figs, units, factors of 10^n [1] $\rho = 8.9 \times 10^3$ [kg m^{-3}] Accept $\rho = 8.87 \times 10^3$ [kg m^{-3}] [1] Percentage (or fractional) unc =0.07[2] (or 7[.2]%)] **or by implic** [1] $\rho = (8.9 \pm 0.6$ [or 0.7]) $\times 10^3$ [kg m^{-3}] **accept** $\rho = (8.87 \pm 0.64) \times 10^3$ [kg m^{-3}] [1]	1	1 1 1		4	2	4
		(ii)		Division of density by atomic mass even if error in units [1] 8.4×10^{28} [m^{-3}] **ecf** on ρ, no sig fig penalty [1]		2		2	1	2
	(b)	(i)	I	Correct transpos'n at any stage of pV=nRT **or** $pV = NkT$ [1] Correct insertion of data, including T = 288 K in $pV = NkT$ **or** in $pV = nRT$ giving n = 42[.2] [mol] **or by implic** from N [1] N = 2.5[4] $\times 10^{25}$ [m^{-3}] [1]		3		3	2	
			II	Gas mainly empty space (between molecules) [but atoms packed/bonded together in solid] [1] Gas molecules are moving about at high speeds [so could be said to take up more space than vibrating atoms in solid] **or** molecules themselves are of comparable size [1]	1		1	2		
		(ii)	I	Correct use of $\frac{1}{2}mc_{rms}^2 = \frac{3}{2}kT$ or equivalent [1] Convincing algebra [1]	1	1		2		
			II	$\frac{c_{rms}\text{ for nitrogen}}{c_{rms}\text{ for oxygen}}$ =1.07 **or equiv or by implic** [1] 7 % [1]			2	2	1	
				Question 6 total	**3**	**9**	**3**	**15**	**6**	**6**

#5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	(a)	(i)	pV evaluated (or equivalent) at two or more points, at least one of which isn't at an extreme end of the curve (1) Conclusion correctly argued (for example, constant pV implies constant temperature) or simply finding equal temps from two points. [For this mark accept both extremes, A and B.] (1) T = 362 K (1)			3	3	2	
		(ii)	Reasonable method used to find 'area' under graph (1) W = 230 [± 50] kJ (1)	1	1		2	1	
		(iii)	Internal energy doesn't change [as temp doesn't change significantly] , [accept $\Delta U = 0$] (1) But an amount of heat flows into the system equal to work done [by the gas] (1)			2	2		
	(b)		1 mark each for up to two 'isolated' points such as • Compressed air car can't go as far per 'fill' / lower range • Compressed air car won't pollute [locally] [accept cleaner power source] • Car may be quieter running off compressed air 1 extra mark available for developing the first bullet eg ... Car has to do work against resistive forces (and sometimes against pull of gravity) hence use of fuel, compressed air etc. Car won't go [nearly] as far on *same volume* of compressed air as petrol or much larger compressed air storage vessel will be needed than petrol tank for car to be able to go as far. 1 extra mark available for developing the second bullet... Car won't pollute But work (or energy) needed to compress the gas Probably involves burning fuel in a power station			3	3		
			Question 8 total	**1**	**1**	**8**	**10**	**3**	**0**

#6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)		Plates of X are closer together (than plates of Y) or vice-versa [1] X contains dielectric (or space between plates of X contains material of higher permittivity) or vice-versa [1] **Accept:** Overlap of plates in X > overlap of plates in Y	2			2		
	(b)	(i)	Series combination: Substitution - $\frac{1}{C_{series}} = \frac{1}{20\,[\mu F]} + \frac{1}{30\,[\mu F]}$ or $C_{series} = \frac{20 \times 30}{20 + 30}$ [μF] [1] C_{series} = 12 μ[F] [1] Total capacitance = 52 μ[F] [1]	1 1	1		3	2	
		(ii)	Idea that Q is same on both capacitors, either stated or e.g. $C \propto \frac{1}{V}$ [1] 20 [× 10^{-6}] × pd across C_2 = 30 [× 10^{-6}] × pd across C_3 [1] [Both marks can be awarded if this seen]	1	1		2	1	
		(iii)	40 [V]		1		1	1	
		(iv)	C_1 stores the greatest charge with explanation: Largest capacitance **and** greatest pd across it [1] Q = 40 × 10^{-6} × 100 = 0.004 [C] [1]	1	1		2	1	
	(c)		Substitution: E = ½ × 1.6 × 10^{-3} × $(300)^2$ [1] E = 72 [J] [1] Energy gained by Al block = $mc\Delta\theta$ or substitution seen i.e. E = 0.1 × 910 × 0.6 [1] E = 54.6 [J] [1] Efficiency (%) = $\frac{54.6ecf \times 100}{72ecf}$ = 75.8 % ∴ Not justified / criteria not met [1]			5	5	3	
			Question 3 total	**6**	**4**	**5**	**15**	**8**	**0**

#7

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)		Ice at 0 °C, boiling water at 100 °C or by implication [1] A correct strategy, e.g. comparing $\frac{131}{96}$ with $\frac{373}{273}$ [1] Convincingly carried through, e.g. $\frac{131}{96} = 1.36$, $\frac{373}{273} = 1.37$ [1] **Alternative:** $\frac{p}{T} = \frac{nR}{V}$ = constant if V of cylinder is constant (1) $\frac{96}{T} = \frac{131}{(T+100)}$ (1) So $35T = 9\,600$ and $T = 274$ [K] so absolute zero = –274 [°C] (1)	1	1 1		3	1	3
		(ii)		At absolute zero the energy of particles in a body is the lowest it can possibly be, or equivalent	1			1		
	(b)	(i)		pV is the same at A and C so temperature the same or equiv [1] $T = \frac{200000 \times 0.01}{0.85 \times 8.31}$ **transposed** or by impl [1] $T = 283$ [K] **no ecf** [1]		3		3	2	
		(ii)		Work over AB = 0. Work over BC = [–] 200 000 × 0.01 J or by implication [1] Work on gas = 2 000 [J] [1]		2		2	1	
		(iii)		A and C at same temp so [for ideal gas] $\Delta U = 0$ [1] So heat out = Work in **or** $Q = \Delta U + W = 0 + (-2000\ \text{J})$ [1] So 2000 [J] of heat flows out [1]	1	1 1		3	1	
				Question total	**3**	**9**	**0**	**12**	**5**	**3**

#8

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Circuit that will supply power to heating coil. Accept cell or battery symbol for power supply or unclear symbol for power supply if labelled. (1) Ammeter and voltmeter correctly connected. (1)	2			2		2
		(ii)	Heat loss [begins to show at higher temperatures] (1) Insulate (lag) the cylinder (1)			2	2		2
		(iii)	Reasonable max gradient line drawn through error bars and triangle or pair of points ≥ half grid width shown (1) Same for min gradient (1) Maximum gradient between 0.200 and 0.230 [°C s^{-1}] (1) Minimum gradient between 0.170 and 0.190 [°C s^{-1}] (1) No sig fig penalty		4		4	4	4
		(iv)	$VIt = mc\,(\theta - \theta_0)$ or $VI(\Delta)t = mc\,\Delta\theta$ (1) $\theta = \frac{VI}{mc}t + \theta_0$ or $\frac{\Delta\theta}{\Delta t} = \frac{VI}{mc}$ (1) [Hence gradient = $\frac{VI}{mc}$]		2		2	2	2
		(v)	Values of V, I, m and gradient(s) (max and min or mean) put into $c = \frac{VI}{m \times \text{gradient}}$ **or** by implication (1) Mean of extreme gradients taken **or** mean of extreme c values. (**ecf** on values whose mean is taken; this is a process mark) No sig fig penalty (1) Mean c value consistent with gradients and to **max of 3 sig figs** (**ecf**) and with correct **units** [e.g. 448 J kg^{-1} $°C^{-1}$or 450 J kg^{-1} $°C^{-1}$] (1) Extreme gradients put into % unc equation **or** half range of extreme c values calculated or by implication (1) Value of absolute unc evaluated correctly to 1 sig fig **ecf** (1) Accept 2 sig figs	1 1	1 1 1		5	5	5
	(b)	(i)	$\Delta U = \frac{3}{2} \times 0.031 \times 8.31 \times (424 - 295)$ [J] or by implication [ΔU = 49.85 J](1) $W = 95 \times 10^3 \times (1.15 - 0.80) \times 10^{-3}$ [J] or by implication [W = 33.3 J] (1) $Q = 83$ [J] **ecf** on ΔU or W (1)	1 1	1		3	3	3
		(ii)	Heat inflow depends on work done [as well as temperature rise] or equivalent (1) Work related to volume change e.g. [if no volume change no work done] (1)			2	2		2
			Question total	**6**	**10**	**4**	**20**	**14**	**20**