

MOMENTUM

IB Physics HL

Thermodynamics - Set 1 - Markscheme

B.1-B.4 | First assessment 2025 | Higher Level

Independent examination-style practice material

10 original problems

Task 01 - Compression of an ideal gas

Paper 2 style | IB code B.3 | Total [7]

Part	Marking guidance	Marks
(a)	$P_1V_1 = P_2V_2$ gives $P_2 = 3.00 \times 10^5 \text{ Pa}$.	2
(b)	Work on gas = $nRT \ln(V_1/V_2) = P_1V_1 \ln 3 = 264 \text{ J}$.	3
(c)	For an isothermal ideal-gas process $\Delta U = 0$, so 264 J of heat leaves the gas.	2

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Task 02 - Molecular motion and pressure

Paper 2 style | IB code B.3 | Total [6]

Part	Marking guidance	Marks
(a)	Uses $v_{\text{rms}} = \sqrt{3kT/m}$, giving 517 m s^{-1} .	3
(b)	Higher temperature means greater mean kinetic energy; collisions with the walls are more frequent and transfer more momentum per collision.	3

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Task 03 - Ice added to a calorimeter

Paper 2 style | IB code B.1 | Total [7]

Part	Marking guidance	Marks
(a)	Water cooling to 0 C releases 63.0 kJ. Heating and melting ice requires $2.10 + 33.4 = 35.5$ kJ, so all ice melts.	3
(b)	Remaining 27.5 kJ heats 0.600 kg water, giving $T_f = 10.9$ C.	4

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Task 04 - Work along a straight path on a p-V diagram

Paper 2 style | IB code B.3 | Total [5]

Part	Marking guidance	Marks
(a)	Area under the straight line is average pressure times Delta V: $W = 2.50 \times 10^5 (3.00 \times 10^{-3}) = 750 \text{ J}$.	3
(b)	First law $\Delta U = Q - W$ gives $Q = 1250 \text{ J}$.	2

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Task 05 - A rectangular thermodynamic cycle

Paper 2 style | IB code B.3 | Total [5]

Part	Marking guidance	Marks
(a)	Enclosed area gives $W_{\text{net}} = \Delta P \Delta V = 600 \text{ J}$.	2
(b)	At maximum PV, $T = PV/R = 144 \text{ K}$.	2
(c)	Internal energy is a state function and the gas returns to its initial state.	1

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Task 06 - A Carnot heat engine

Paper 2 style | IB code B.4 | Total [6]

Part	Marking guidance	Marks
(a)	$\eta = 1 - T_c/T_h = 0.500$.	2
(b)	$W = \eta Q_h = 1.20 \text{ kJ}$ and $Q_c = 1.20 \text{ kJ}$.	3
(c)	Real processes include irreversibility such as friction and finite-temperature heat transfer.	1

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Task 07 - A refrigerator

Paper 2 style | IB code B.4 | Total [5]

Part	Marking guidance	Marks
(a)	$\text{COP}_{\text{max}} = T_{\text{c}}/(T_{\text{h}} - T_{\text{c}}) = 9.00.$	2
(b)	$P_{\text{min}} = \dot{Q}_{\text{c}}/\text{COP} = 16.7 \text{ W}.$	2
(c)	$\text{COP}_{\text{real}} = 150/60.0 = 2.50.$	1

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Task 08 - Heat conduction through a composite wall

Paper 2 style | IB code B.1 | Total [6]

Part	Marking guidance	Marks
(a)	Uses thermal resistances in series: $R = L1/(k1A) + L2/(k2A) = 0.1806 \text{ K W}^{-1}$, so rate = $25/0.1806 = 138 \text{ W}$.	3
(b)	Temperature drop through brick is $138(0.100/(0.600(12))) = 1.92 \text{ K}$, so interface temperature is 18.1 C .	3

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Task 09 - Thermal radiation from a star

Paper 2 style | IB code B.2 | Total [7]

Part	Marking guidance	Marks
(a)	$\lambda_{\text{max}} = b/T = 5.00 \times 10^{-7} \text{ m}$.	2
(b)	$L = 4 \pi R^2 \sigma T^4 = 3.90 \times 10^{26} \text{ W}$.	3
(c)	Luminosity changes by $1.10^4 = 1.464$, an increase of 46.4%.	2

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Task 10 - Newton's law of cooling

Paper 2 style | IB code B.1 | Total [6]

Part	Marking guidance	Marks
(a)	Uses $T - T_{\text{room}} = (T_0 - T_{\text{room}})e^{(-kt)}$: $30/60 = e^{(-10k)}$, so $k = 0.0693 \text{ min}^{-1}$.	3
(b)	$T = 20 + 60e^{(-0.0693(25))} = 30.6 \text{ C}$.	2
(c)	Examples: changing room temperature, significant radiation nonlinearity, or changing convection conditions.	1

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