MOMENTUM

IB Physics HL

Thermodynamics - Set 1

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

Independent examination-style practice material

10 original problems

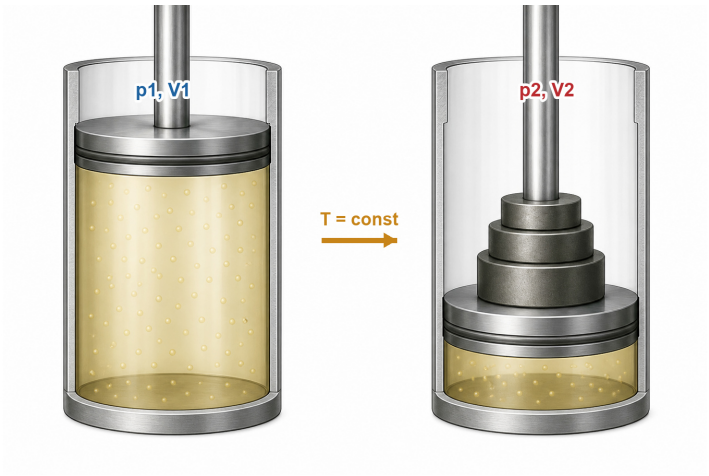
TASK 01

[7]

Compression of an ideal gas

Paper 2 style | IB code B.3

A fixed amount of ideal gas occupies 2.40e-3 m^3 at 1.00e5 Pa and 300 K. It is compressed isothermally to 8.00e-4 m^3.



(a) Determine the final pressure. [2]

(b) Determine the work done on the gas. [3]

(c) Determine the heat transferred to or from the gas. [2]

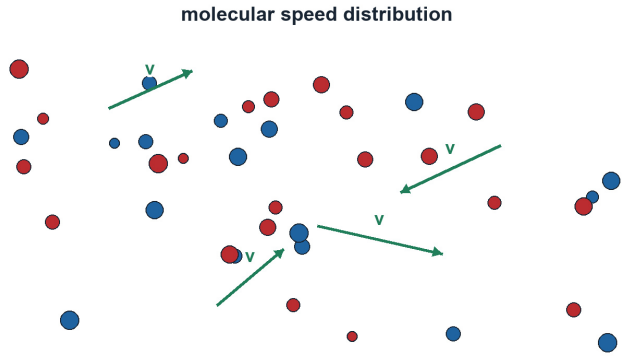
TASK 02

[6]

Molecular motion and pressure

Paper 2 style | IB code B.3

Nitrogen gas at 300 K is modelled as an ideal gas. The mass of one molecule is 4.65e-26 kg.



(a) Determine the rms molecular speed. [3]

(b) Explain microscopically why pressure rises when the gas is heated at constant volume. [3]

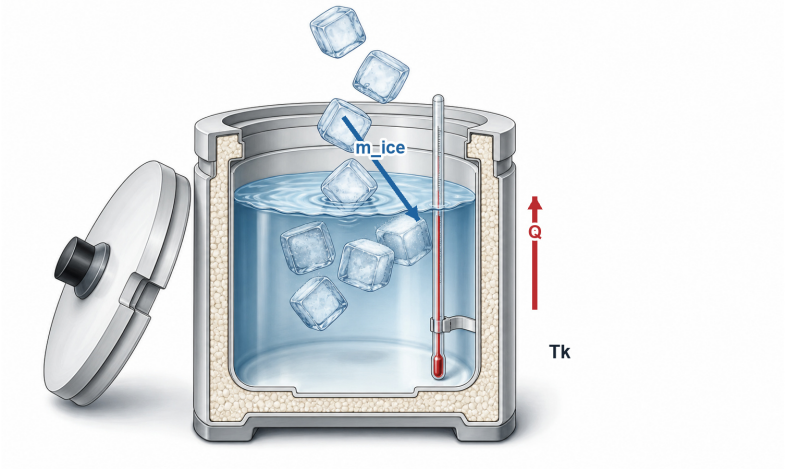
TASK 03

[7]

Ice added to a calorimeter

Paper 2 style | IB code B.1

A well-insulated container holds 0.500 kg of water at 30.0 C. A 0.100 kg piece of ice at -10.0 C is added. Use c_water = 4200 J kg^{-1} K^{-1}, c_ice = 2100 J kg^{-1} K^{-1} and L_f = 3.34e5 J kg^{-1}.



(a) Determine whether all the ice melts. [3]

(b) Determine the final equilibrium temperature. [4]

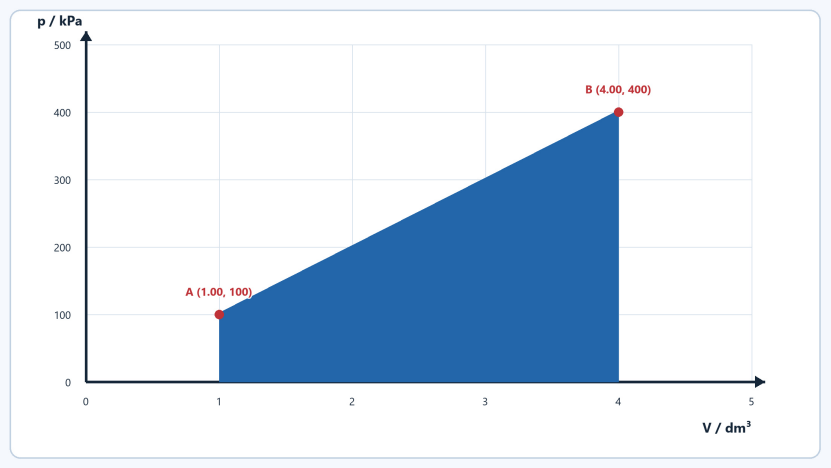
TASK 04

[5]

Work along a straight path on a p-V diagram

Paper 2 style | IB code B.3

A gas changes from (V,P) = (1.00e-3 m^3, 1.00e5 Pa) to (4.00e-3 m^3, 4.00e5 Pa) along a straight line on a p-V diagram. Its internal energy increases by 500 J.



(a) Determine the work done by the gas. [3]

(b) Determine the heat supplied to the gas. [2]

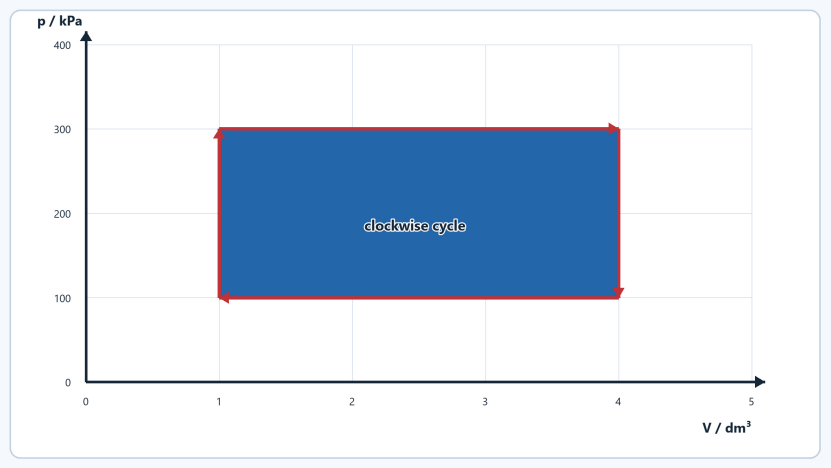
TASK 05

[5]

A rectangular thermodynamic cycle

Paper 2 style | IB code B.3

One mole of monatomic ideal gas follows a clockwise rectangular cycle between pressures 1.00e5 Pa and 3.00e5 Pa and volumes 1.00e-3 m^3 and 4.00e-3 m^3.



(a) Determine the net work per cycle. [2]

(b) Determine the highest temperature in the cycle. [2]

(c) Explain why the net change in internal energy over a complete cycle is zero. [1]

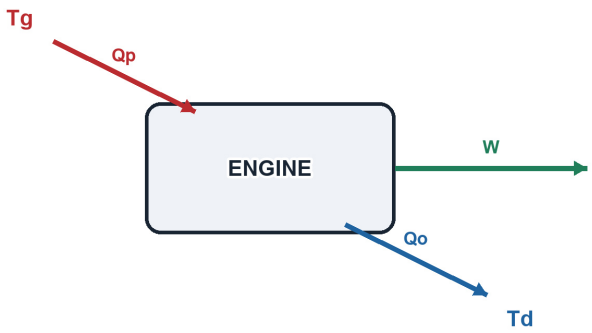
TASK 06

[6]

A Carnot heat engine

Paper 2 style | IB code B.4

A reversible engine operates between reservoirs at 600 K and 300 K and absorbs 2.40 kJ per cycle from the hot reservoir.



(a) Determine its maximum efficiency. [2]

(b) Determine the work output and heat rejected per cycle. [3]

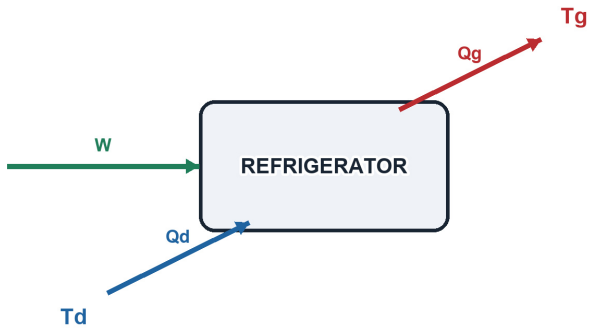
(c) State why a real engine operating between these temperatures has lower efficiency. [1]

TASK 07
[5]

A refrigerator

Paper 2 style | IB code B.4

A refrigerator removes heat at 150 W from a compartment at 270 K while the room is at 300 K.



(a) Determine the maximum theoretical coefficient of performance. [2]

(b) Determine the minimum input power. [2]

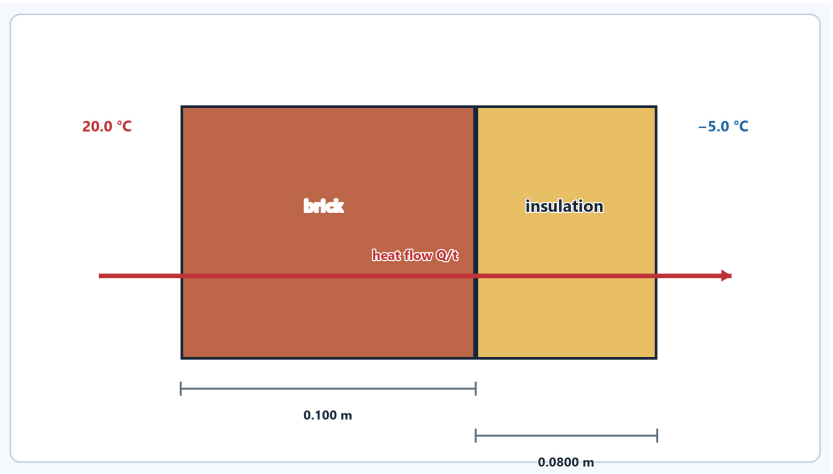
(c) A real refrigerator requires 60.0 W. Determine its coefficient of performance. [1]

TASK 08
[6]

Heat conduction through a composite wall

Paper 2 style | IB code B.1

A wall of area 12.0 m^2 consists of 0.100 m brick with k = 0.600 W m^{-1} K^{-1} and 0.0800 m insulation with k = 0.0400 W m^{-1} K^{-1}. The surface temperatures are 20.0 C and -5.0 C.



(a) Determine the steady heat-transfer rate. [3]

(b) Determine the temperature at the interface. [3]

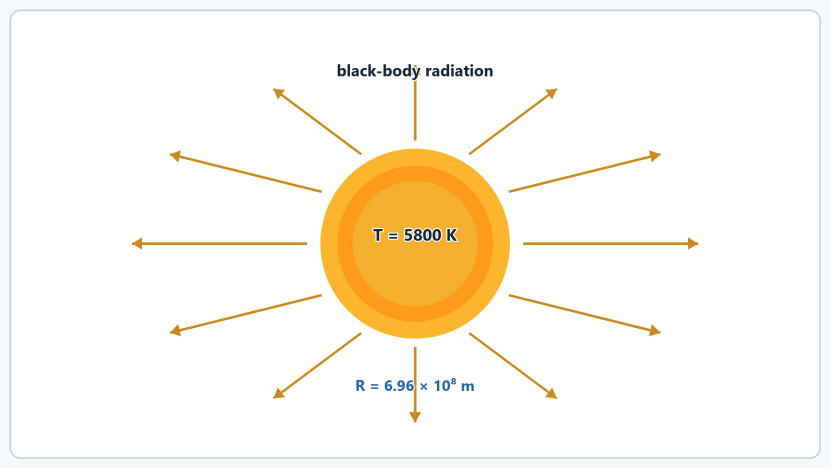
TASK 09

[7]

Thermal radiation from a star

Paper 2 style | IB code B.2

A star has surface temperature 5800 K and radius 6.96e8 m. Treat it as a black body. Use sigma = 5.67e-8 W m^{-2} K^-4 and Wien constant 2.90e-3 m K.



(a) Determine the wavelength of peak emission. [2]

(b) Determine the luminosity. [3]

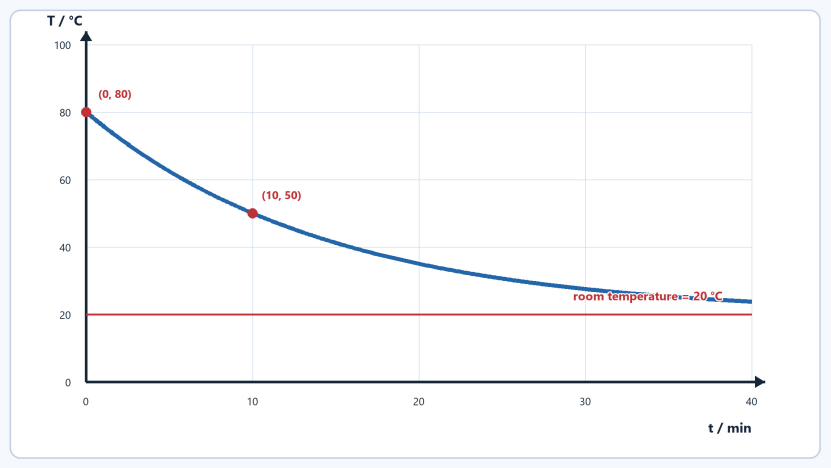
(c) Determine how luminosity changes if temperature rises by 10.0% at constant radius. [2]

TASK 10
[6]

Newton's law of cooling

Paper 2 style | IB code B.1

An object cools in a room at 20.0 C. Its temperature is 80.0 C initially and 50.0 C after 10.0 min. Assume Newton's law of cooling.



(a) Determine the cooling constant in min^{-1}. [3]

(b) Determine the temperature after 25.0 min. [2]

(c) State one condition under which the model may become inaccurate. [1]