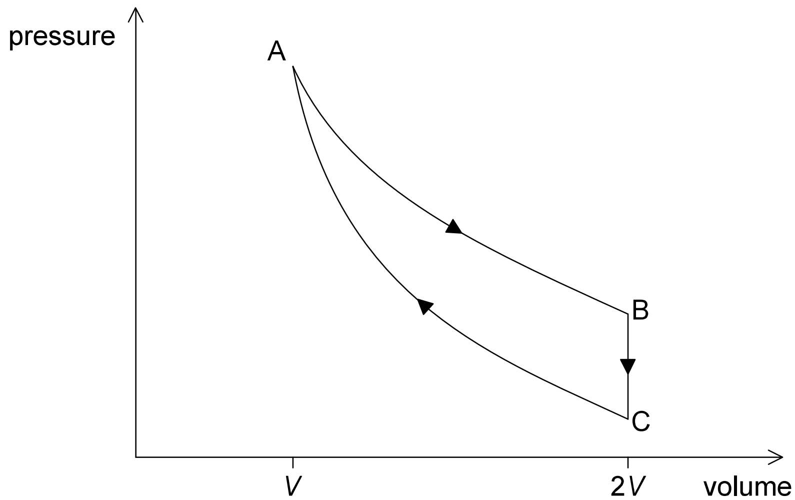
(Option B continued)

9. A heat engine operates on the cycle shown in the pressure–volume diagram. The cycle consists of an isothermal expansion AB, an isovolumetric change BC and an adiabatic compression CA. The volume at B is double the volume at A. The gas is an ideal monatomic gas.



At A the pressure of the gas is 4.00×10^{6} Pa, the temperature is 612 K and the volume is 1.50×10^{-4} m^3. The work done by the gas during the isothermal expansion is 416 J.

(a) (i) Justify why the thermal energy supplied during the expansion AB is 416 J. [1]

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(ii) Show that the temperature of the gas at C is 386 K. [2]

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(Option B continues on the following page)

(Option B, question 9 continued)

(iii) Show that the thermal energy removed from the gas for the change BC is approximately 330 J. [2]

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(iv) Determine the efficiency of the heat engine. [2]

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(b) State and explain at which point in the cycle ABCA the entropy of the gas is the largest. [3]

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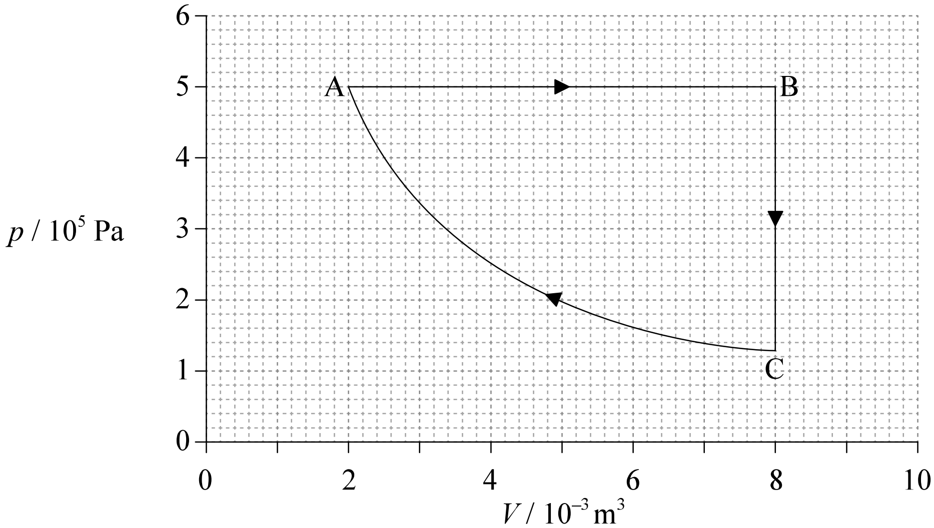
(Option B continues on page 21)

(Option B continued)

9. The pressure volume (pV) diagram shows a cycle ABCA of a heat engine. The working substance of the engine is a fixed mass of an ideal gas.



The temperature of the gas at A is 400 K.

(a) Calculate the maximum temperature of the gas during the cycle. *[1]*

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(Option B continues on the following page)

(Option B, question 9 continued)

(b) For the isobaric expansion AB, calculate the

(i) work done by the gas. *[2]*

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(ii) change in the internal energy of the gas. *[1]*

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(iii) thermal energy transferred to the gas. *[1]*

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(Option B continues on the following page)

(Option B, question 9 continued)

(c) The work done on the gas during the isothermal compression is 1390 J. Determine the change in entropy of the gas for this compression. *[2]*

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(d) Determine the efficiency of the cycle ABCA. *[2]*

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(e) State whether the efficiency of a Carnot engine operating between the same temperatures as those operating in cycle ABCA on page 18, would be greater than, equal to, **or** less than the efficiency in (d). *[1]*

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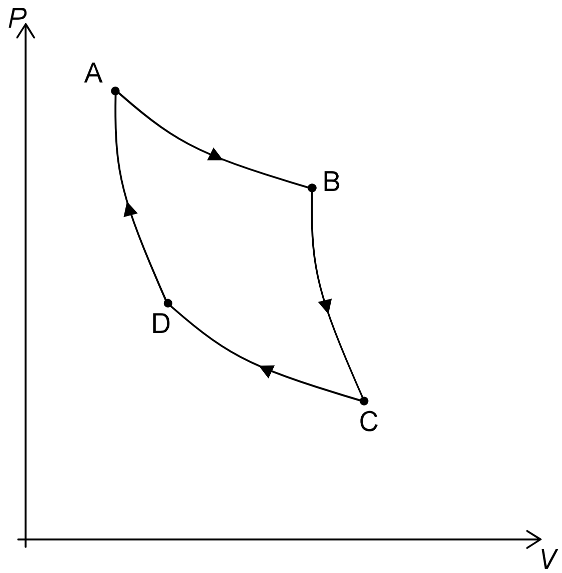
(Option B continues on page 22)

(Option B continued)

8. The P–V diagram of the Carnot cycle for a monatomic ideal gas is shown.



(a) State what is meant by an adiabatic process. [1]

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(b) Identify the two isothermal processes. [1]

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(c) The system consists of 0.150 mol of a gas initially at A. The pressure at A is 512 kPa and the volume is $1.20 \times 10^{-3}\,m^3$.

(i) Determine the temperature of the gas at A. [2]

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(Option B continues on the following page)

(Option B, question 8 continued)

(ii) The volume at B is $2.30 \times 10^{-3}\,m^3$. Determine the pressure at B. [2]

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(d) At C the volume is V_C and the temperature is T_C.

(i) Show that $P_B V_B^{\frac{5}{3}} = nRT_C V_C^{\frac{2}{3}}$. [1]

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(ii) The volume at C is $2.90 \times 10^{-3}\,m^3$. Calculate the temperature at C. [2]

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(e) State a reason why a Carnot cycle is of little use for a practical heat engine. [1]

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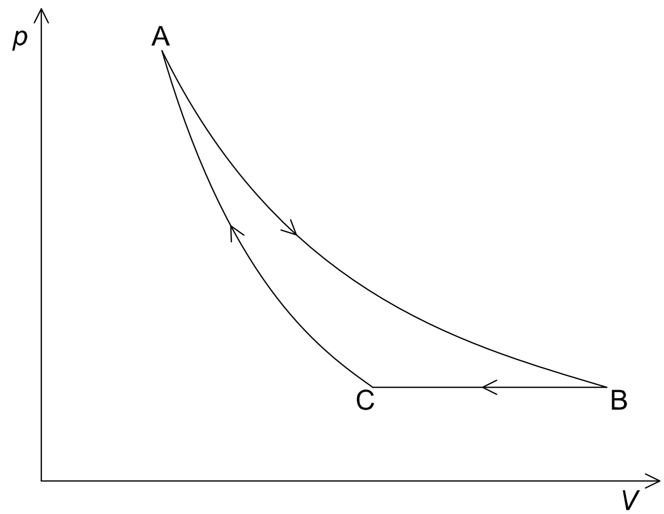
(Option B continues on the following page)

(Option B continued)

9. The pV diagram of a heat engine using an ideal gas consists of an isothermal expansion A → B, an isobaric compression B → C and an adiabatic compression C → A.



The following data are available:

Temperature at A	$= 385\ \text{K}$
Pressure at A	$= 2.80 \times 10^{6}\ \text{Pa}$
Volume at A	$= 1.00 \times 10^{-4}\ \text{m}^3$
Volume at B	$= 2.80 \times 10^{-4}\ \text{m}^3$
Volume at C	$= 1.85 \times 10^{-4}\ \text{m}^3$

(Option B continues on the following page)

(Option B, question 9 continued)

(a) Show that at C the

(i) pressure is 1.00×10^6 Pa. [2]

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(ii) temperature is 254 K. [2]

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(b) Show that the thermal energy transferred from the gas during the change B $\rightarrow$ C is 238 J. [3]

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(Option B continues page 19)

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Answers written on this page
will not be marked.

(Option B, question 9 continued)

(c) (i) The work done by the gas from A → B is 288 J. Calculate the efficiency of the cycle. [2]

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(ii) State, without calculation, during which change (A → B, B → C or C → A) the entropy of the gas decreases. [1]

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(Option B continues on the following page)