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QUESTION WORKBOOK

The first law of thermodynamics

Engineering physics · Year 13

AQA 3.11.2.1, 3.11.2.2, 3.11.2.3 · CIE 16.1.2, 16.2.1, 16.2.2 · OCR A 5.1.2(f), 5.1.4(i)

17 questions · 51 marks

NAVY SCREEN EDITION

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SECTION A · Warm-up

A1 State the first law of thermodynamics, and state what Q and W each stand for in the form used at A-level. [2]

A2 State what is meant by the internal energy of an ideal gas, and state the one property of the gas that fixes it. [2]

A3 State which term of the first law is zero for a change at constant volume, and which is zero for an isothermal change, giving a reason in each case. [2]

A4 State what is meant by an adiabatic change, and give one practical example. [2]

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A5 Explain why the work done by an expanding gas is equal to the area under the curve on a p-V diagram. [2]

A6 State the sign of W in $Q = \Delta U + W$ when a gas is compressed. [1]

SECTION B · Standard

B1 A gas absorbs 850 J of heat while expanding and does 320 J of work on its surroundings. Calculate the change in its internal energy and state whether its temperature rises or falls. [3]

B2 The area under the p-V curve for an expanding gas is estimated by counting squares: 34 squares, each representing 25 J. During the expansion 1200 J of heat is supplied to the gas. Calculate the work done by the gas and the change in its internal energy. [3]

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B3 A gas is compressed adiabatically, 500 J of work being done on it. State the value of Q, calculate the change in internal energy, and state what happens to the temperature of the gas. [3]

B4 A gas at a pressure of 2.4×10^5 Pa occupies 3.0×10^{-3} m^3. It expands isothermally to 8.0×10^{-3} m^3. Calculate the final pressure and state, with a reason, the direction of the heat flow. [3]

B5 Air at 1.0×10^5 Pa fills 6.0×10^{-4} m^3 of a cylinder and is compressed adiabatically to 1.2×10^{-4} m^3. Calculate the final pressure. Take $\gamma = 1.4$. [3]

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B6 A gas is sealed in a rigid container and supplied with 1200 J of heat. It is then cooled, losing 400 J of heat. For each stage state the work done by the gas and calculate the change in internal energy, and give the overall change. [3]

B7 A gas expands at a constant pressure of 8.0×10^4 Pa, its volume increasing from 1.5×10^{-3} m^3 to 6.5×10^{-3} m^3, while 620 J of heat is supplied. Calculate the work done by the gas and the change in its internal energy. [3]

SECTION C · Stretch

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C1 A fixed mass of gas is taken round the following four-stage cycle. From A (1.0×10^5 Pa, 1.0×10^{-3} m^3) it is heated at constant volume to B (3.0×10^5 Pa). From B it expands at constant pressure to C (3.0×10^{-3} m^3). From C it is cooled at constant volume to D (1.0×10^5 Pa). From D it is compressed at constant pressure back to A. Calculate the work done by the gas in each stage, the net work per cycle, and the net heat supplied per cycle. [6]

C2 In a diesel engine, air at 1.0×10^5 Pa and 300 K fills 9.0×10^{-4} m^3 of a cylinder and is compressed adiabatically to 5.0×10^{-5} m^3. Take $\gamma = 1.4$. Calculate the final pressure and the final temperature, and explain why no spark plug is needed. [5]

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C3 A gas expands from the same initial state to the same final volume, once isothermally and once adiabatically. Explain which expansion does more work, and account for the difference using the first law. [4]

C4 A fixed mass of gas undergoes three changes in succession. First it absorbs 500 J of heat at constant volume. Then it expands isothermally, doing 380 J of work. Finally it is compressed adiabatically, 260 J of work being done on it. Calculate the change in internal energy in each change and the overall change, and show that the ledger balances. [4]

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