1. This question is about thermodynamic processes.

(a) Distinguish between an *isothermal* process and an *adiabatic* process as applied to an ideal gas.

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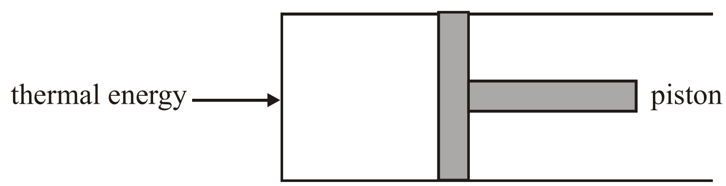
(2)

An ideal gas is held in a container by a moveable piston and thermal energy is supplied to the gas such that it expands at a constant pressure of 1.2×10^5 Pa.



The initial volume of the container is 0.050 m^3 and after expansion the volume is 0.10 m^3. The total energy supplied to the gas during the process is 8.0×10^3 J.

(b) (i) State whether this process is **either** isothermal **or** adiabatic **or** neither.

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(1)

(ii) Determine the work done by the gas.

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(1)

(iii) Hence calculate the change in internal energy of the gas.

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(2)
(Total 6 marks)

2. This question is about modelling the thermal processes involved when a person is running.

When running, a person generates *thermal energy* but maintains approximately constant *temperature*.

(a) Explain what *thermal energy* and *temperature* mean. Distinguish between the two concepts.

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(4)

The following simple model may be used to estimate the rise in temperature of a runner assuming no thermal energy is lost.

A closed container holds 70 kg of water, representing the mass of the runner. The water is heated at a rate of 1200 W for 30 minutes. This represents the energy generation in the runner.

(b) (i) Show that the thermal energy generated by the heater is 2.2×10^6 J.

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(2)

(ii) Calculate the temperature rise of the water, assuming no energy losses from the water. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

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(3)

(c) The temperature rise calculated in (b) would be dangerous for the runner. Outline **three** mechanisms, other than evaporation, by which the container in the model would transfer energy to its surroundings.

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(6)

A further process by which energy is lost from the runner is the evaporation of sweat.

(d) (i) Percentage of generated energy lost by sweating: 50%
Specific latent heat of vaporization of sweat: 2.26×10^6 J kg^{-1}

Using the information above, and your answer to (b)(i), estimate the mass of sweat evaporated from the runner.

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(3)

(ii) State and explain **one** factor that affects the rate of evaporation of sweat from the skin of the runner.

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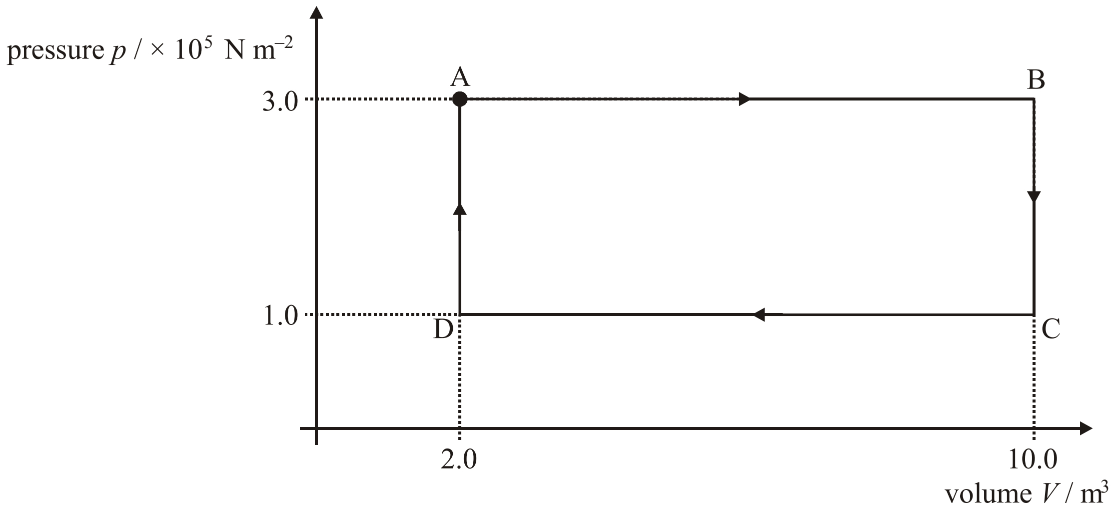
(2)
(Total 20 marks)

3. This question is about the thermodynamics of a heat engine.

In an idealized heat engine, a fixed mass of a gas undergoes various changes of temperature, pressure and volume. The *p*-*V* cycle (A→B→C→D→A) for these changes is shown in the diagram below.



(a) Use the information from the graph to calculate the work done during **one** cycle.

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(2)

(b) During one cycle, a total of 1.8×10^6 J of thermal energy is ejected into a cold reservoir. Calculate the efficiency of this engine.

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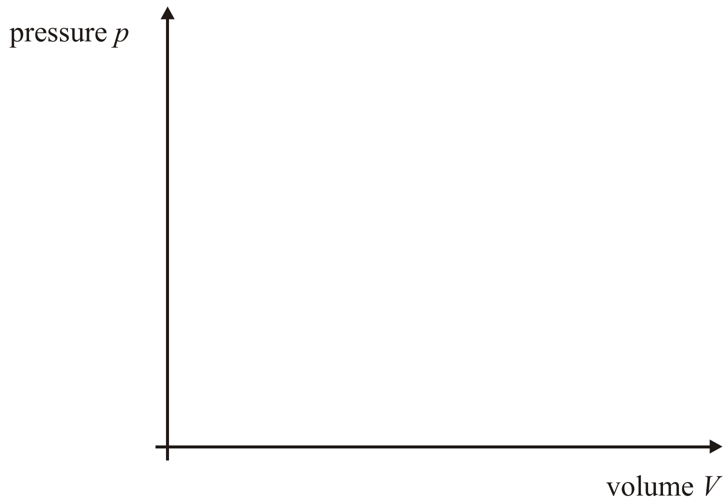
(2)

(c) Using the axes below, sketch the p-V changes that take place in the fixed mass of an ideal gas during one cycle of a *Carnot engine*. *(Note this is a sketch graph – you do not need to add any values.)*



(2)

(d) (i) State the names of the **two** types of change that take place during one cycle of a Carnot engine.

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(2)

(ii) Add labels to the above graph to indicate which parts of the cycle refer to which particular type of change.

(2)

(Total 10 marks)