Practice Question Set For A-Level
Subject : Physics
Paper-3 Topic: Section B (Section 11_ Engineering Physics)

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Name of the Student:____

Max. Marks : 18 Marks **Time : 18 Minutes**

Q1.

Flywheels store energy very efficiently and are being considered as an alternative to battery power.

(a) A flywheel for an energy storage system has a moment of inertia of 0.60 kg m^2 and a maximum safe angular speed of 22 000 rev min^{-1}.

Show that the energy stored in the flywheel when rotating at its maximum safe speed is 1.6 MJ.

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(2)

(b) In a test the flywheel was taken up to maximum safe speed and then allowed to run freely until it came to rest. The average power dissipated in overcoming friction was 8.7 W.

Calculate

(i) the time taken for the flywheel to come to rest from its maximum speed,

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(ii) the average frictional torque acting on the flywheel.

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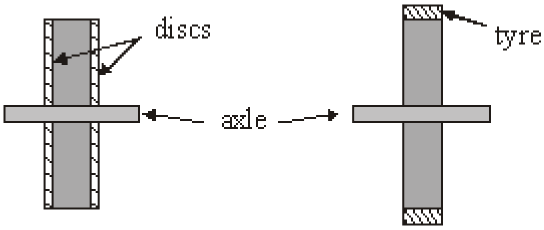
(2)

(c) The energy storage capacity of the flywheel can be improved by adding solid discs to the flywheel as shown in cross-section in **A** in the figure below, or by adding a hoop or tyre to the rim of the flywheel as shown in **B** in the same diagram. The same mass of material is added in each case. State, with reasons, which arrangement stores the more energy when rotating at a given angular speed.



(2)
(Total 6 marks)

Q2.

(a) The coefficient of performance of a refrigerator is given by

$$COP_{ref} = \frac{Q_{out}}{Q_{in} - Q_{out}}$$

With reference to a refrigerator, explain the terms Q_{in} and Q_{out}.

(2)

(b) A refrigerator is designed to make ice at –10 °C from water initially at room temperature. The energy needed to make 1.0 kg of ice at –10 °C from water initially at room temperature is 420 kJ. The refrigerator has a coefficient of performance of 4.5.

(i) Calculate the power input to the refrigerator if it is required to make 5.5 kg of ice every hour.

answer = ______________________ W

(2)

(ii) Calculate the rate at which energy is delivered to the surroundings of the refrigerator.

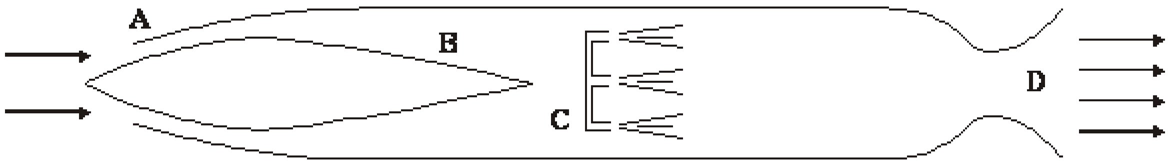
answer = ______________________ W

(1)

(Total 5 marks)

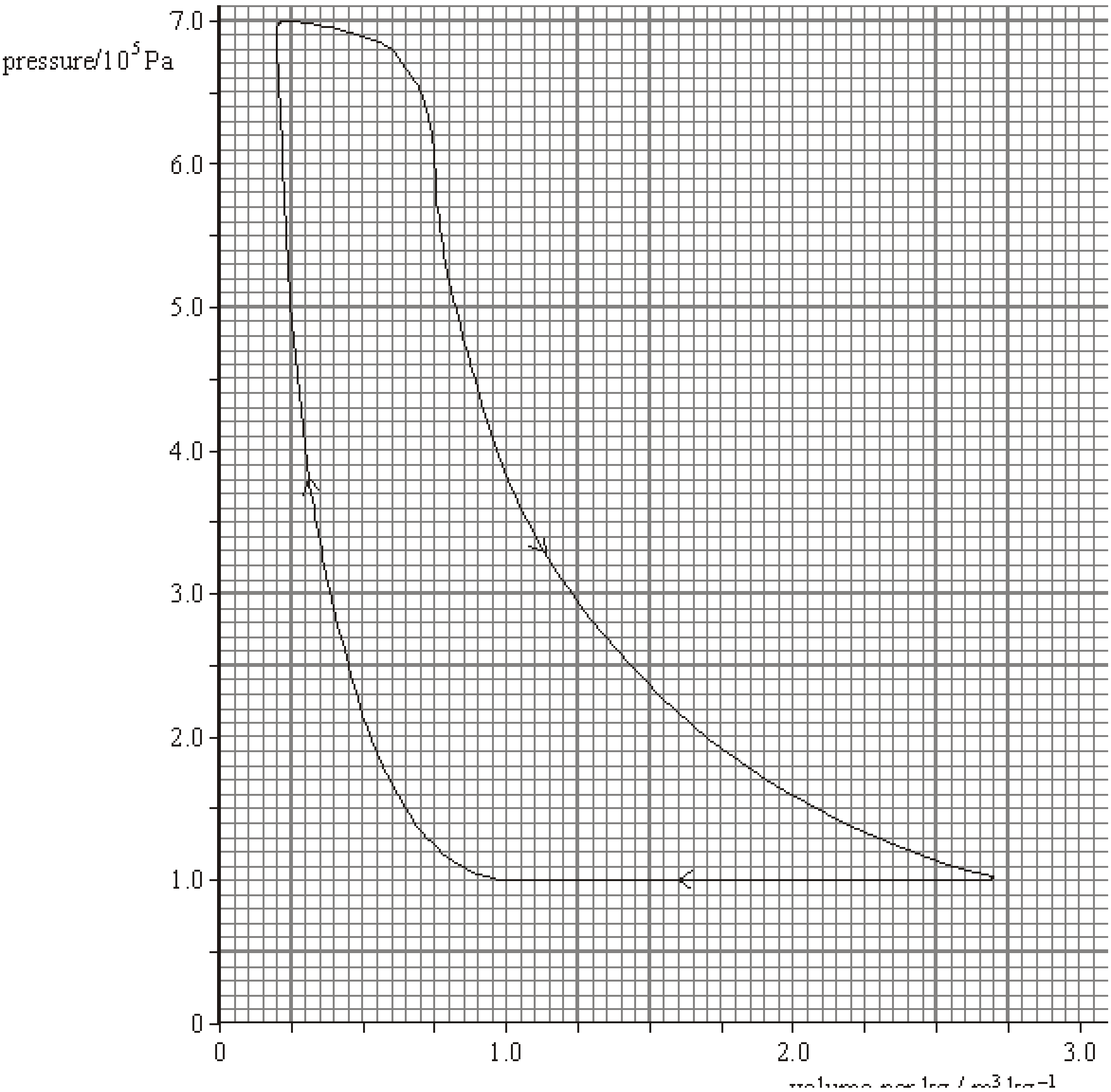
Q3.

The ram jet engine was used as a cheap and efficient propulsion unit for high speed guided missiles. The figure below shows a section through this engine.



When moving at high speed, air enters the nose at **A** and its pressure increases up to region **B**. At **C**, fuel is injected directly into the air stream where it is ignited, and the burning gases are exhausted at high speed through the nozzle at **D**. This provides the thrust.

The graph shows the pressure-volume diagram for 1.0 kg of air passing through the engine. Note that the volume axis has units of $m^3\ kg^{-1}$ i.e. the volume for every kg of air that passes through the engine.



(a) (i) Use the graph to show that the work done for every kg of air that passes through the engine is about 500 kJ.

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(ii) The mass flow rate of the air through the engine is 9.9 kg s^{-1}. Determine the work done in one second in the engine. This is the equivalent of the indicated power of the engine.

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(iii) Because of the high speed of the air in the engine, there is significant frictional heating amounting to a power loss of 430 kW. Determine the power output of the engine (available for thrust).

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(5)

(b) The engine consumes fuel at the rate of 0.30 kg per second. The calorific value of the fuel is 44 MJ kg^{-1}. Calculate

(i) the input power to the engine,

(ii) the overall efficiency of the engine.

(2)

(Total 7 marks)