Name of the Student:_____
Max. Marks : 24 Marks **Time : 24 Minutes**

Q1.

(a) A metal flywheel is rotating on frictionless bearings. The temperature is increased so that the flywheel expands.

Consider **each** of the following statements and indicate with a tick (✔) if it is correct.

	✔ if correct
The moment of inertia will decrease.	
The angular velocity will decrease.	
The angular momentum will be unaltered.	

(1)

An electric motor drives a machine which stamps out shapes from sheet steel. The machine is fitted with a flywheel of moment of inertia 25 kg m^2 which is accelerated uniformly until it is rotating at 640 rev min^{-1}. The machine then starts a stamping operation which reduces the flywheel's angular speed to 360 rev min^{-1}.

(b) Explain why a flywheel is fitted between the motor and the stamping machine.

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(2)

(c) Calculate the energy needed for the stamping operation.

energy _____ J

(2)

(d) Immediately after the stamping operation the flywheel is accelerated to its initial speed of 640 rev min^{-1} in a time of 5.0 s. The next stamping operation then begins.

Calculate the constant torque provided by the motor during this 5.0 s. Assume that the bearing frictional torque is negligible.

torque = _____ N m

(2)

(e) Calculate the minimum power output of the electric motor required.

power _____ W

(2)

(f) The flywheel is a solid disc. It is to be replaced with a flywheel which gives a smaller angular speed change for each stamping operation.

Two replacement flywheels, **A** and **B**, are available and information about them and the original flywheel is given in the table below.

flywheel	**density of material / kg m^{-3}**	**thickness of disc / m**	**outer radius / m**
original	7800	0.10	0.38
A	8800	0.20	0.30
B	2900	0.10	0.50

Deduce which flywheel, **A** or **B**, would be more suitable. Explain your choice.

The moment of inertia I of a solid disc of mass m and outer radius r about an axis through the centre is given by

$$I = \frac{1}{2} m r^2$$

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(3)

(Total 12 marks)

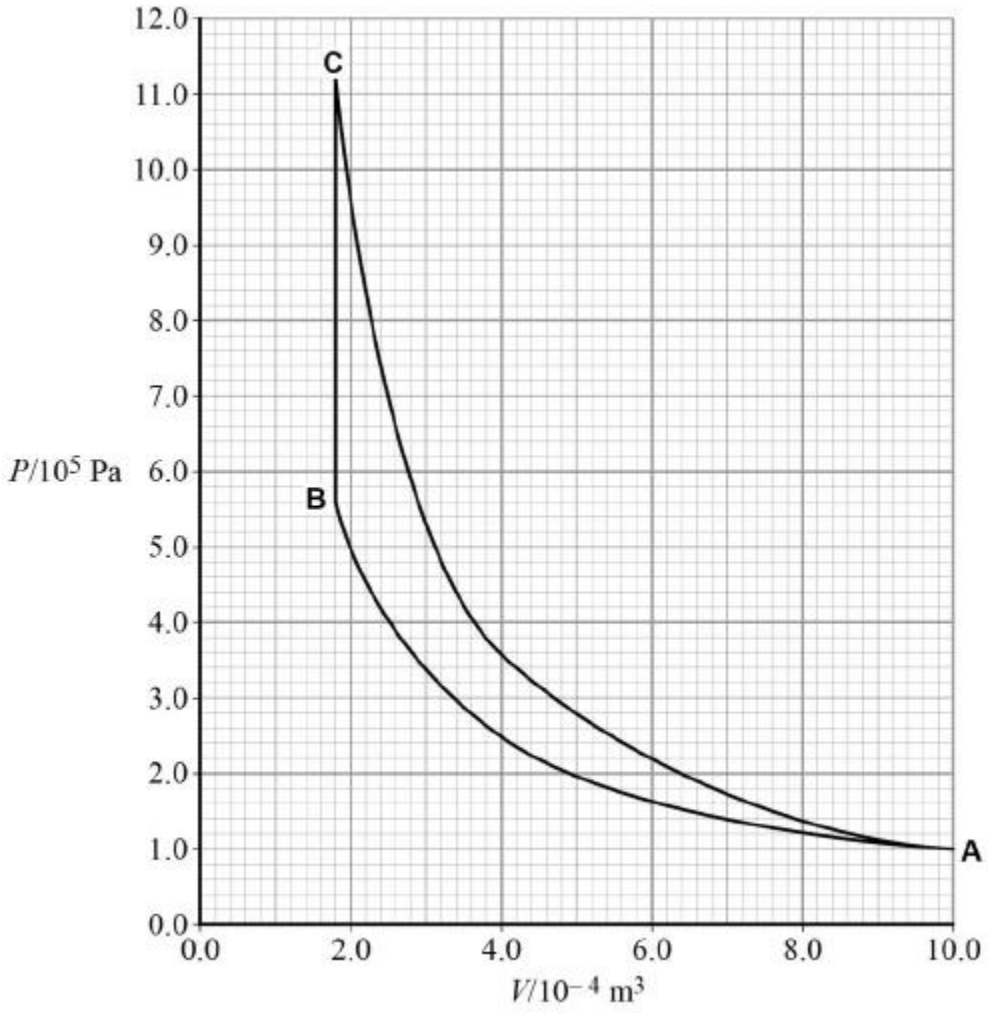
Q2.

The graph below shows a $p - V$ diagram of a theoretical engine cycle in which a fixed mass of gas at an initial pressure of 1.00 ×10^5 Pa and temperature 295 K is taken through the following stages in turn:

A ⟶ **B** isothermal compression

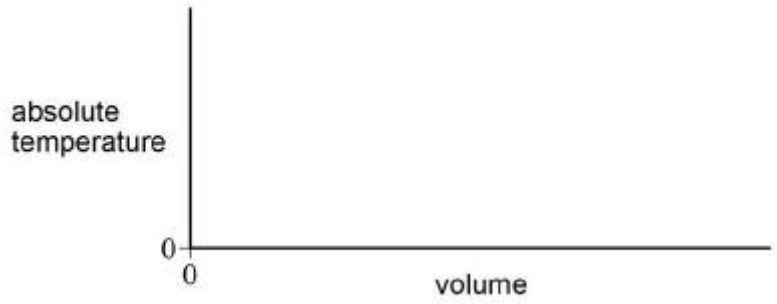
B ⟶ **C** heat addition of 251 J at constant volume to a temperature 2.0 times the initial temperature

C ⟶ **A** adiabatic expansion to the initial temperature and pressure.



(a) Sketch, on the axes below, a graph to show how the temperature will vary with volume during

the cycle. Label the points **A**, **B** and **C**.



(2)

(b) Determine the work output of the cycle.

work = _____ J

(3)

(c) Determine the power output of this theoretical engine if the engine were to run at 80 cycles per second.

power = _____ W

(1)

(d) An engineer is thinking about designing a real engine which works as closely as possible to this cycle.

Discuss some of the problems that will have to be overcome. Go on to discuss, with reference to the power output and efficiency of the cycle, whether the engineer should go ahead with the design.

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(6)

(Total 12 marks)