Name:

**1.** This question is about entropy changes.

(a) State what is meant by an *increase in entropy* of a system.

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**(1)**

(b) State, in terms of entropy, the second law of thermodynamics.

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**(2)**

(c) When a chicken develops inside an egg, the entropy of the egg and its contents decreases. Explain how this observation is consistent with the second law of thermodynamics.

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**(2)**

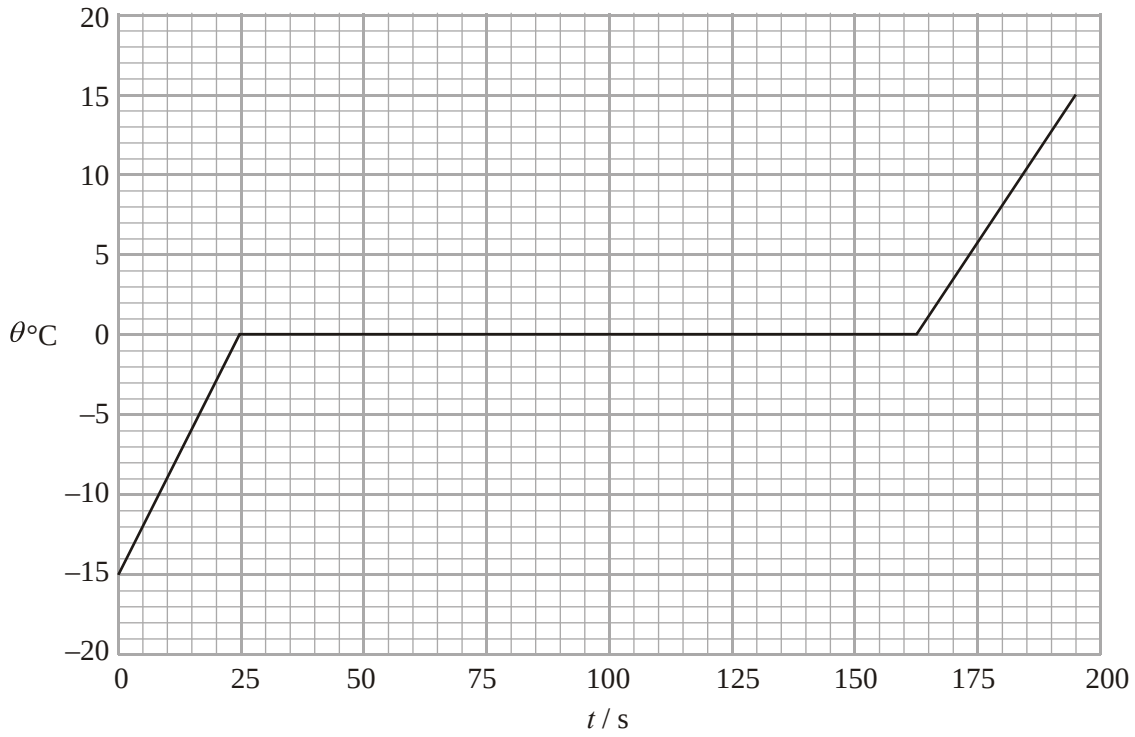
**(Total 5 marks)**

**2.** This question is about the change of phase (state) of ice.

A quantity of crushed ice is removed from a freezer and placed in a calorimeter. Thermal energy is supplied to the ice at a constant rate. To ensure that all the ice is at the same temperature, it is continually stirred. The temperature of the contents of the calorimeter is recorded every 15 seconds.

Name:

The graph below shows the variation with time $t$ of the temperature $\theta$ of the contents of the calorimeter. *(Uncertainties in the measured quantities are not shown.)*




(a) On the graph above, mark with an X, the data point on the graph at which all the ice has just melted.

**(1)**

(b) Explain, with reference to the energy of the molecules, the constant temperature region of the graph.

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**(3)**

The mass of the ice is 0.25 kg and the specific heat capacity of water is 4200 $Jkg^{-1}K^{-1}$.

(c) Use these data and data from the graph to

(i) deduce that energy is supplied to the ice at the rate of about 530 W.

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**(3)**

(ii) determine the specific heat capacity of ice.

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**(3)**

(iii) determine the specific latent heat of fusion of ice.

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**(2)**

(d) State what property of the molecules of the ice is measured by a change in entropy.

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**(1)**

(e) State, in terms of entropy change, the second law of thermodynamics.

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..... **(1)**

(f) State what happens to the entropy of water as it freezes. Outline how this change in entropy is consistent with the second law of thermodynamics.

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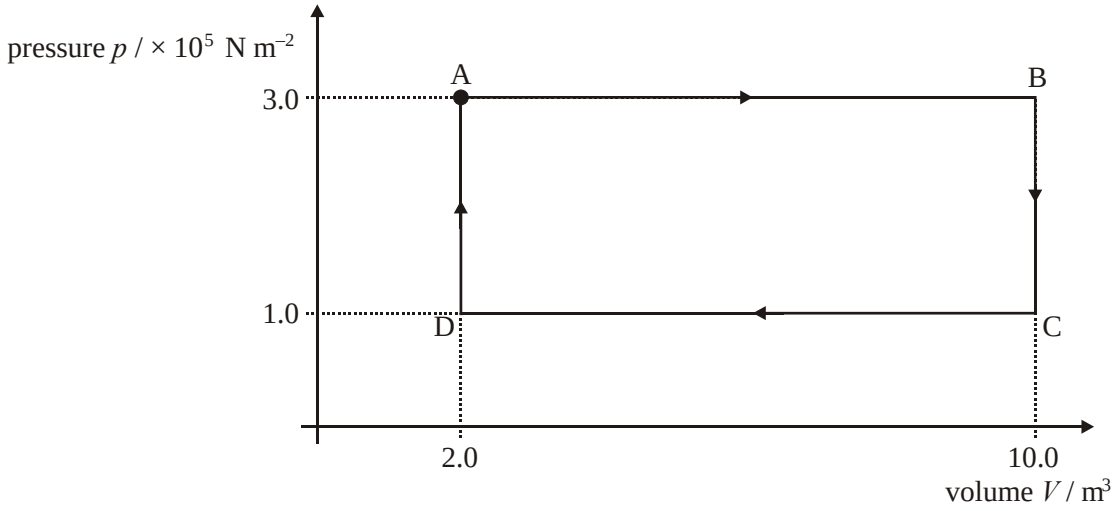
**(4)**

**(Total 18 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)**

Name:

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

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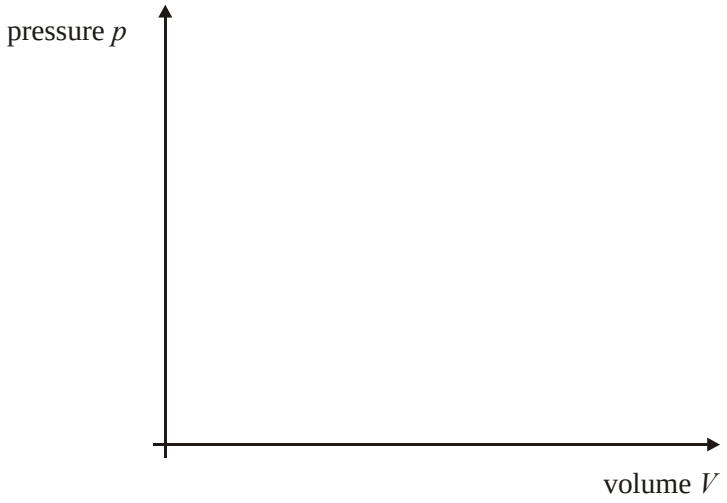
**(2)**

(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)**

Name:

**4.** 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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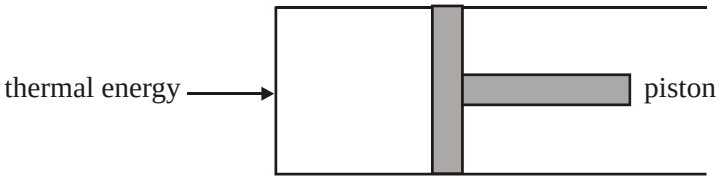
**(2)**

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 $1.2 \times 10^5$ 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 $8.0 \times 10^3$ 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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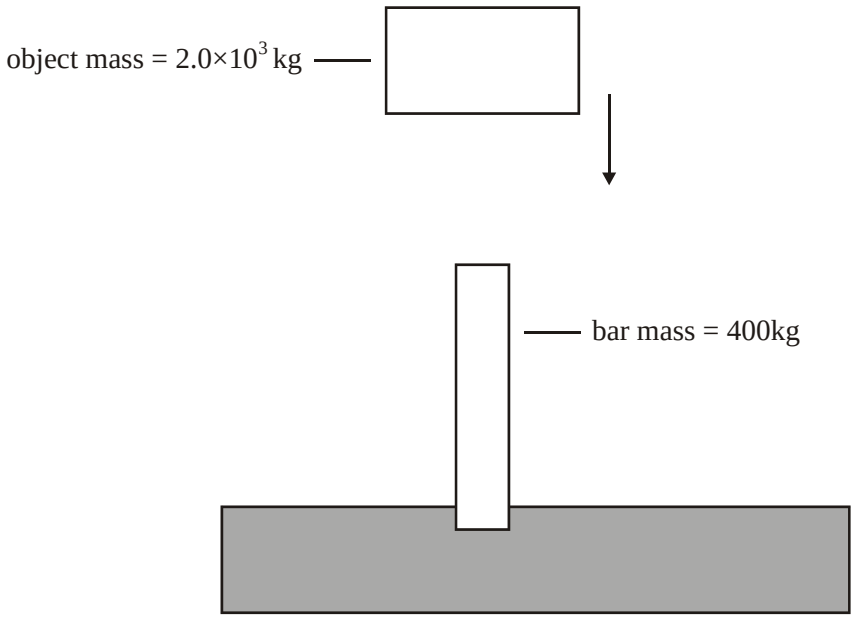
**(2)**

**(Total 6 marks)**

Name:

**5.** This question is about driving a metal bar into the ground and the engine used in the process.

Large metal bars can be driven into the ground using a heavy falling object.




In the situation shown, the object has a mass $2.0 \times 10^3$ kg and the metal bar has a mass of 400 kg.

The object strikes the bar at a speed of 6.0 m $s^{-1}$ It comes to rest on the bar without bouncing. As a result of the collision, the bar is driven into the ground to a depth of 0.75 m.

(a) Determine the speed of the bar immediately after the object strikes it.

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**(4)**

(b) Determine the average frictional force exerted by the ground on the bar.

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**(3)**

(c) The object is raised by a diesel engine that has a useful power output of 7.2 kW.

In order that the falling object strikes the bar at a speed of 6.0m $s^{-1}$, it must be raised to a certain height above the bar. Assuming that there are no energy losses due to friction, calculate how long it takes the engine to raise the object to this height.

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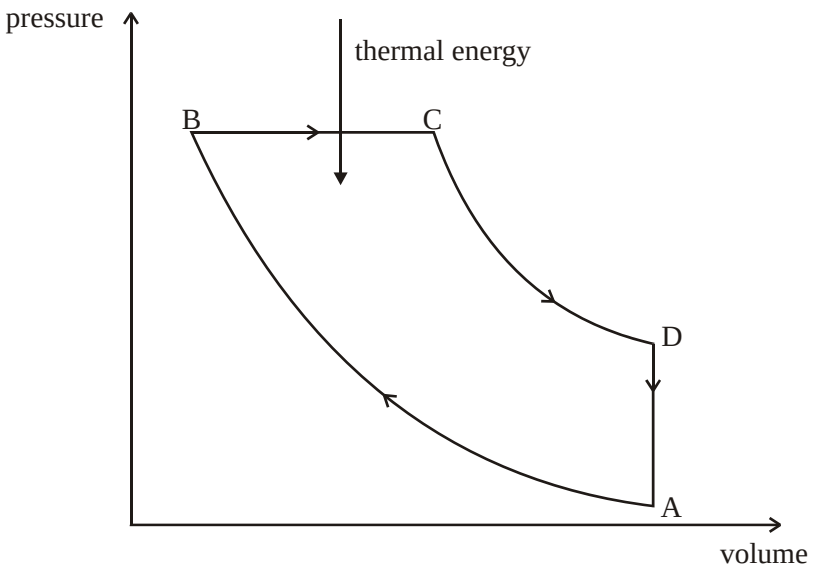
**(4)**

The diagram below shows the relation between the pressure and the volume of the air in the diesel engine for one cycle of operation of the engine. During the cycle there are two adiabatic processes, an isochoric process and an isobaric process.




(d) Explain what is meant by

(i) an adiabatic process.

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**(2)**

(ii) an isochoric process.

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**(1)**

(iii) an isobaric process.

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**(1)**

(e) Identify, from the diagram, the following processes.

(i) Adiabatic processes

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**(1)**

(ii) Isochoric process

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**(1)**

(iii) Isobaric process

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**(1)**

During the process B $\rightarrow$ C thermal energy is absorbed.

The diesel engine has a total power output of 8.4 kW and an efficiency of 40%. The cycle of operation is repeated 40 times every second.

(f) State what quantity is represented on the diagram by the area ABCD.

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**(1)**

(g) Determine the value of the quantity that is represented by the area ABCD.

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**(1)**

Name:

(h) Determine the thermal energy absorbed during the process B $\rightarrow$ C.

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**(2)**
**(Total 22 marks)**