6 (a) (i) State the assumption of the kinetic theory of gases that explain why gas molecules could stay above ground.

.... [1]

(ii) The pressure P exerted by an ideal gas is given by the expression

$$P = \frac{1}{3}\rho\langle c^2\rangle$$

where ρ is the density of the gas and $\langle c^2\rangle$ the mean square speed of the gas.

Starting with one gas molecule of mass, m, moving with speed c_x in the x-direction in a cubic container with length L, show how the above expression can be derived. Define any symbols used.

[5]

(b) **(i)** Explain what is meant by *specific latent heat of vaporisation.*

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) A sample of ethanol of mass 0.35 kg is vaporised at its boiling point of 78 °C, under an atmospheric pressure of 1.0×10^5 Pa.

Specific latent heat of vaporization = 0.95×10^6 J kg^{-1}
Density in liquid state = 790 kg m^{-3}
Density in gaseous state = 1.6 kg m^{-3}

1. Calculate the work done *by* the gas.

work done *by* gas = …………………………….. J [2]

2. Calculate the heat supplied into the system.

heat supplied into system = …………………………….. J [1]

3. Hence, calculate the increase in internal energy of the system.

increase in internal energy = …………………………….. J [2]

(c) A student determines the specific heat capacity of a liquid using the apparatus shown in Fig. 6.1 below.

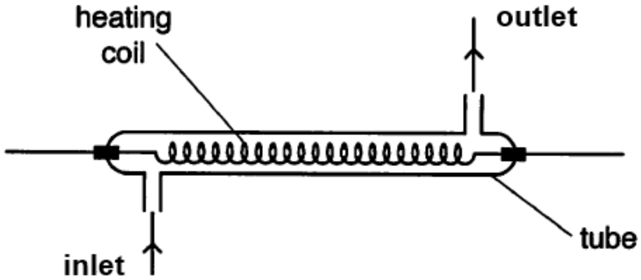

Fig. 6.1

The liquid flows through the tube at 0.15 kg min^{-1}, while the heater provides power at 25 W. The temperatures of the liquid at the inlet and outlet are 15 °C and 19 °C respectively. With the inlet and outlet temperatures unchanged, the flow rate increased to 0.23 kg min^{-1} and the power of the heater increased to 37 W.

(i) Determine the rate of heat loss of the liquid.

rate of heat loss = …………………………….. W [2]

(ii) Explain why it is necessary for the inlet and outlet temperatures to remain unchanged.

………………………………………………………………………………………………..

……………………………………………………………………………………………… [1]

(d) The Otto Thermodynamic Cycle shows the pressure-volume (p-V) processes of internal combustion engines such as those used in airplane and car engines.

The cycle uses the following processes

A → B **Intake stroke**, gas is drawn into the cylinder at constant pressure.

B → C **Compression stroke**, *adiabatic* compression of air in the cylinder back to the original volume with no fuel added.

C → D **Rapid Combustion** at constant volume where pressure and temperature increase.

D → E **Expansion (Power) stroke**, *adiabatic* expansion as the pressure decreases.

E → B **Heat Rejection**, the ejection of spent, hot gases. The net volume change in this process is zero as the pressure adjusts back to the initial pressure.

B → A **Exhaust stroke**, as the piston moves back into the cylinder, the volume of gas decreases at constant pressure back to the initial stage.

(i) On the p-V axes below, complete the graph that represents the full Ideal Otto Cycle showing the processes **B** → **C** → **D** → **E** → **B** with the stages **C**, **D** and **E** clearly labelled. [3]

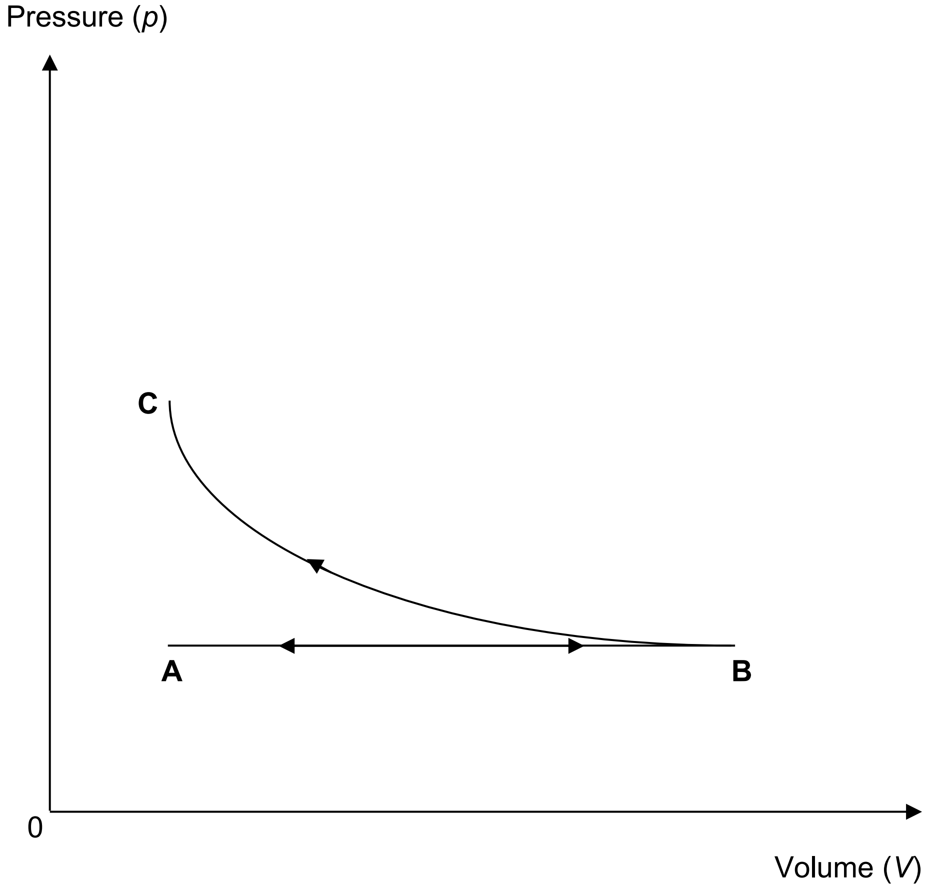

Fig. 6.2

(ii) Using a feature of the p-V diagram, describe how the power produced by the engine can be determined.

…………………………………………………………………………………………...

…………………………………………………………………………………………. [1]

(iii) In reality, the *ideal* cycle does not occur due to energy losses within each process. Describe how the practical p-V diagram would differ from an ideal one.

…………………………………………………………………………………………...

…………………………………………………………………………………………. [1]