Name of the Student:_____
Max. Marks : 20 Marks **Time : 20 Minutes**

Q1.

In an ideal heat-engine cycle a fixed mass of air is taken through the following four processes.

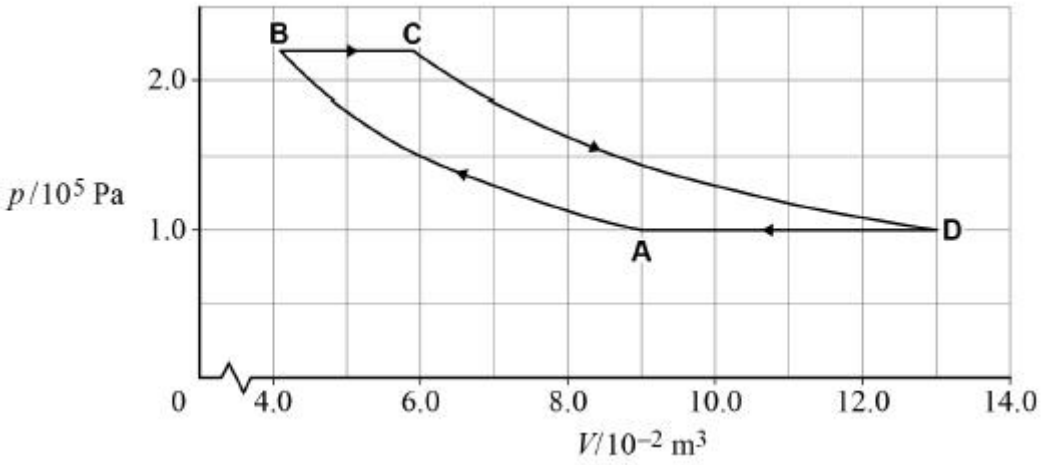
A → B isothermal compression from an initial pressure of 1.0×10^5 Pa and a volume of 9.0×10^{-2} m^3 to a pressure of 2.2×10^5 Pa. The work done on the air is 7100 J.

B → C increase in volume at constant pressure to a volume of 5.9×10^{-2} m^3.

C → D isothermal expansion to a pressure of 1.0×10^5 Pa and a volume of 13×10^{-2} m^3. The work done by the air is 10 300 J.

D → A reduction in volume at constant pressure to the original volume.

The graph below shows the cycle



(a) Show, by calculation, that the volume at **B** is 4.1×10^{-2} m^3.

(1)

(b) The temperature of the air between **A** and **B** is 295 K.

Show that the temperature of the air at **C** is about 420 K.

(2)

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(c) An ideal engine based on this cycle uses a device called an economiser. The economiser stores all the energy transferred in the cooling process **D** → **A** and gives up all this energy to the air in process **B** → **C**.
This means that an external source supplies energy to the air by heating only in process **C** → **D**.

Complete the table to show the values of work done W and energy transfer Q in each of the four processes.
Use the space below the table for any calculations.
Use a consistent sign convention.

Process	Work done W / J	Energy transfer Q / J
A → **B**	−7100	−7100
B → **C**	4000	
C → **D**	10 300	10 300
D → **A**		−14 000

(1)

(d) Explain why W is equal to Q in process **A** → **B** and in process **C** → **D**.

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(2)

(e) It is claimed that the efficiency of this engine cycle is the same as the maximum theoretical efficiency of a heat engine operating between the same temperatures.

Deduce whether this claim is true.

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(3)

(f) Discuss **one** problem that would be faced by an engineer designing a real engine based on this cycle.

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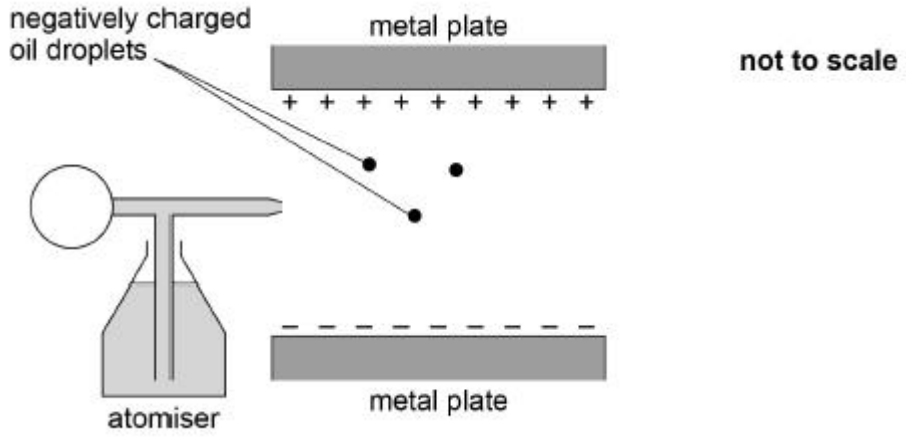
(3)

(Total 12 marks)

Q2.

The diagram shows an experiment to measure the charge of the electron.



Negatively charged oil droplets are sprayed from the atomiser into the gap between the two horizontal metal plates. A potential difference is applied between the metal plates.

One of the droplets remains stationary.

(a) Identify the forces acting on the stationary droplet.
In your answer you should state the relationship between the forces.

The upthrust on the droplet due to the air it displaces is negligible.

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(2)

(b) The potential difference between the plates is changed to zero and the droplet falls at a terminal velocity of 1.0×10^{-4} m s^{-1}.

The density of the oil is 880 kg m^{-3}
The viscosity of air is 1.8×10^{-5} N s m^{-2}

Show that the radius of the droplet is about 1×10^{-6} m.

Assume that the droplet is spherical.

(3)

(c) The potential difference between the plates is restored to its initial value and the droplet becomes stationary.

The charge on the droplet is -4.8×10^{-19} C.

A student suggests that, if the droplet splits into two spheres of equal size, both spheres would remain stationary.

Deduce whether this suggestion is correct.

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(3)
(Total 8 marks)

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