7 **(a)** A power station transmits electricity at a potential difference of 10 kV. An ideal step-down transformer is used to supply electricity to households at 240 V.

(i) The transformer has 4.0×10^4 turns at the primary coil. Determine the number of turns at the secondary coil.

number of turns = ... [1]

(ii) Using Faraday's law of electromagnetic induction, explain why the transformer will not work if a direct current is supplied to the primary coil.

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.....

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..... [2]

(b) An electric heater has the label shown in Fig. 7.1.

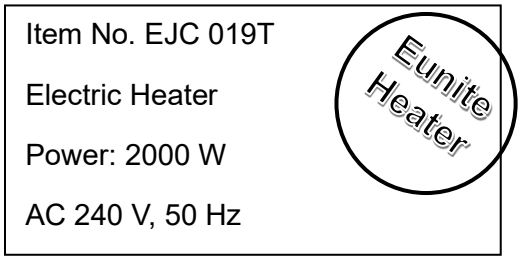

Fig. 7.1

(i) The heater is connected to a household 240 V A.C. supply. The current I that passes through the heater can be expressed as $I = I_0 \sin(\omega t)$.

Determine the values of I_0 and ω.

I_0 = ... A

ω = …… rad s^{-1} [3]

(ii) The heater is then connected in series with a 140 V D.C. supply and a 4.8 Ω resistor as shown in Fig. 7.2.

Show that the power dissipated by the heater is 500 W.

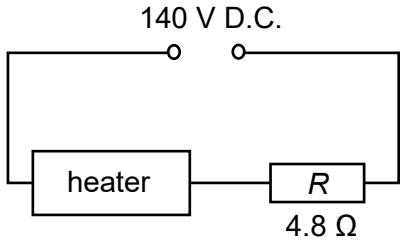

Fig. 7.2

power = ... W [3]

(c) (i) State the first law of thermodynamics.

.....

.....

..... [1]

(ii) The heater in the circuit shown in Fig. 7.2 operates normally for an hour and its temperature remains constant.

1. The rate of increase in internal energy of the heater filament is 0 J s^{-1}. Explain this in terms of kinetic theory.

.....

.....

.....

.....

..... [3]

2. State the rate of heat supplied by the heater filament.

rate of heat supplied = ... J s^{-1} [1]

3. Using the first law of thermodynamics, state and explain the rate of doing work on the filament.

.....

.....

.....

..... [2]

(d) (i) The heater, still connected in the circuit in Fig 7.2, is then placed in a tube through which water flows at a constant rate, as shown in Fig. 7.3.

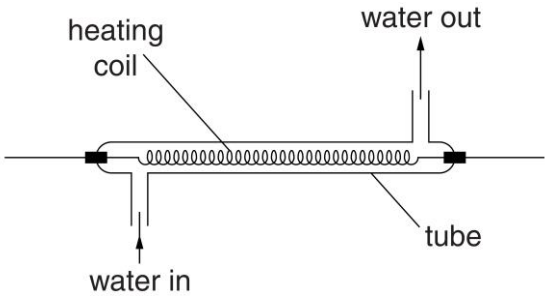

Fig. 7.3

The water flows into the tube at a temperature of 25 °C. The temperature of the water at the outlet is 28 °C. The specific heat capacity of water is 4.2 J g^{-1} K^{-1}.

Calculate the flow rate, in g s^{-1}, of water through the tube.

flow rate = ... g s^{-1} [2]

(ii) State and explain whether your answer in **(d)(i)** is likely to be an overestimate or an underestimate of the flow rate.

.....

.....

.....

..... [1]

(iii) Suggest how the experiment can be modified to improve the estimate of the flow rate.

.....

..... [1]

[Total: 20]