Question 3.

A circuit equivalent to the given one is shown in Fig. 3. In a steady state (the capacitors are completely charged already) the same current I flows through all the resistors in the closed circuit ABFGHDA. From the Kirchhoff's second rule we obtain:

(3.1) $$I = \frac{E_4 - E_1}{4R}.$$

Next we apply this rule for the circuit ABCDA:

(3.2) $$V_1 + IR = E_2 - E_1,$$

where V_1 is the potential difference across the capacitor C_1. By using the expression (3.1) for I, and the equation (3.2) we obtain:

(3.3) $$V_1 = E_2 - E_1 - \frac{E_4 - E_1}{4} = 1\,\text{V}.$$

Similarly, we obtain the potential differences V_2 and V_4 across the capacitors C_2 and C_4 by considering circuits BFGCB and FGHEF:

(3.4) $$V_2 = E_4 - E_2 - \frac{E_4 - E_1}{4} = 5\,\text{V},$$

(3.5) $$V_4 = E_4 - E_3 - \frac{E_4 - E_1}{4} = 1\,\text{V}.$$

Finally, the voltage V_3 across C_3 is found by applying the Kirchhoff's rule for the outermost circuit EHDAH:

(3.6) $$V_3 = E_3 - E_1 - \frac{E_4 - E_1}{4} = 5\,\text{V}.$$

The total energy of the capacitors is expressed by the formula:

(3.7) $$W = \frac{C}{2}\left(V_1^2 + V_2^2 + V_3^2 + V_4^2\right) = 26\,\mu\text{J}.$$

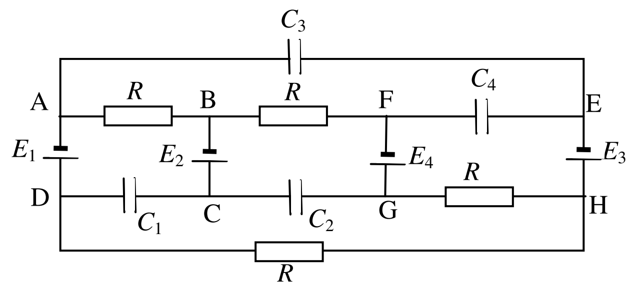

Fig. 3

When points B and H are short connected the same electric current I' flows through the resistors in the BFGH circuit. It can be calculated, again by means of the Kirchhoff's rule, that:

(3.8) $$I' = \frac{E_4}{2R}.$$

The new steady-state voltage on C_2 is found by considering the BFGCB circuit:

(3.9) $$V_2' + I'R = E_4 - E_2$$

or finally:

(3.10) $$V_2' = \frac{E_4}{2} - E_2 = 0\,\mathrm{V}.$$

Therefore the charge q_2' on C_2 in the new steady state is zero.