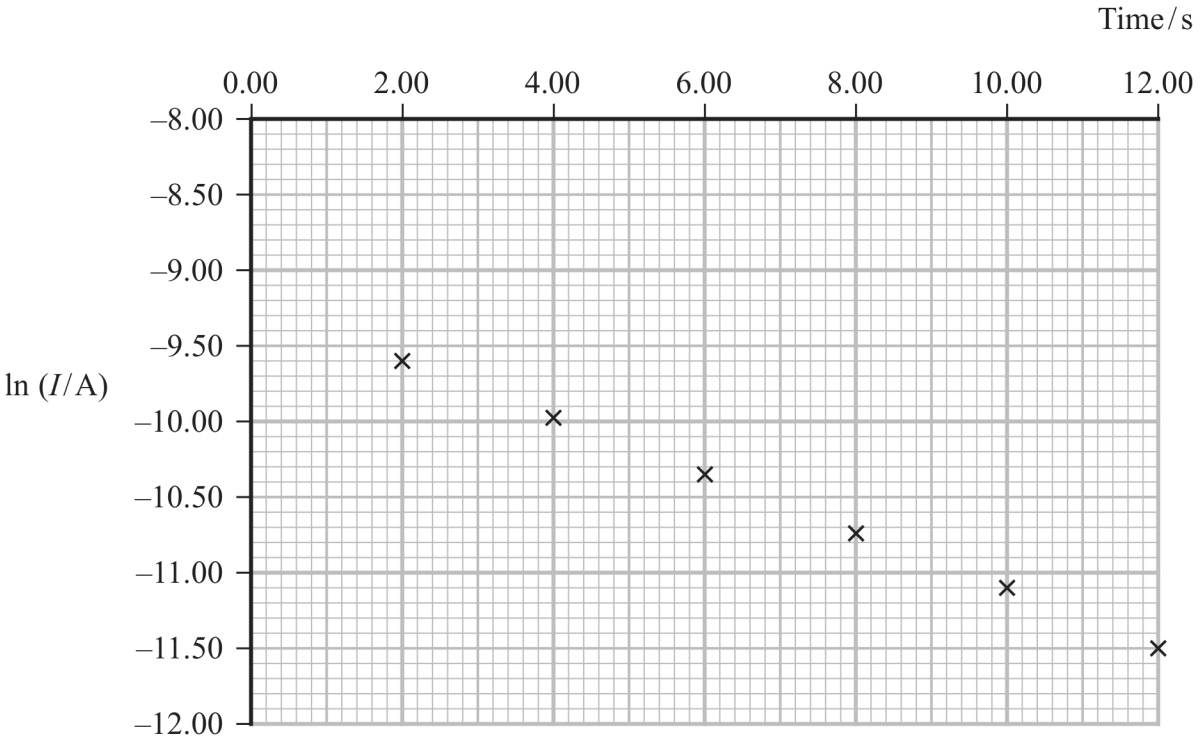
18 A student planned to use a capacitor in a timing circuit.

The capacitor was connected in series with a resistor to determine the capacitance of the capacitor.

The capacitor was charged while measuring the current I in the circuit.

The following graph was plotted.



(a) The value marked on the capacitor is 22 μF.

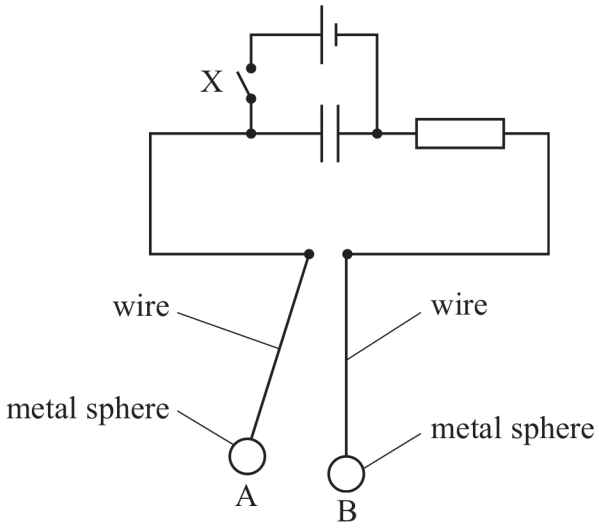
Show that this value is correct.

resistance of resistor = 240 kΩ

(4)

(b) The capacitor was used in a circuit to time a collision between two identical metal spheres.

The spheres were suspended from wires. The wires were connected to the circuit, as shown.



When the wires hang vertically the spheres are in contact and the discharging circuit is complete.

Switch X was closed to charge the capacitor. The switch was then opened and sphere A was released.

Sphere A collided with sphere B.

While the spheres were in contact, the capacitor partially discharged.

Sphere B moved to the right. The maximum height h of sphere B above its starting position was measured.

(i) Calculate the maximum speed of sphere B after the collision.

$h = 1.1\,\text{cm}$
mass of sphere B = 28 g

(3)

Maximum speed = ...

(ii) Calculate the time for which the spheres were in contact.

resistance in circuit = 49 Ω
potential difference across capacitor before collision = 6.18 V
potential difference across capacitor after collision = 5.43 V
capacitance of capacitor = 22 μF

(2)

Time spheres in contact = ...

(iii) The student stated that the average force acting on sphere B cannot be more than the weight of sphere A.

Deduce whether this statement is correct.

mass of each sphere = 28 g

(4)

(Total for Question 18 = 13 marks)