# Electromagnetism and Optics: Class Exam II

 $17\ {\rm March}\ 2022$ 

Name:

Total:

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## Instructions

- There are 9 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

## Physical constants and useful formulae

$e = 1.61 \times 10^{-19} \mathrm{C}$	$q_{\rm electron} = -e$	$q_{\rm proton} = +e$
$m_{\rm electron} = 9.11 \times 10^{-31} \mathrm{kg}$	$m_{\mathrm{proton}} = 1.67 \times$	$10^{-27}  \mathrm{kg}$
$k=9.0\times 10^9{\rm Nm^2/C^2}$	$\epsilon_0 = 8.85 \times 10$	$0^{-12} \mathrm{C}^2/\mathrm{Nm}^2$

## Question 1

In a procedure to coat an object with copper, copper ions flow through a solution and accumulate on the object. Each copper ion has the same charge as two protons. The current (consisting of copper ions) is 0.025 A. Determine the total number of copper ions that accumulate on the object in 30 minutes.

Two capacitors are connected to a battery as illustrated.

a) Determine the charge across each capacitor.



b) Determine the total energy stored in the pair of capacitors.

Resistors, labeled 1, 2, and 3, are connected to an ideal battery as illustrated. The resistances are  $R_1 = 5\Omega$  and  $R_2 = R_3 = 20 \Omega$ . Let  $P_1$  be the power produced by resistor 1,  $P_2$  the power produced by resistor 2 and  $P_3$  the power produced by resistor 3. Which of the following (choose one) is true?

- i)  $P_1 = P_2 = P_3$
- ii)  $P_2 = P_3 < P_1$
- iii)  $P_2 = P_3 > P_1$
- iv)  $P_1 = P_2 < P_3$
- v)  $P_1 < P_2 < P_3$
- vi)  $P_2 < P_1 < P_3$



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#### Question 4

A battery and identical bulbs are connected in the illustrated circuit. Rank the bulbs in order of increasing brightness. Explain your answer.

Determine the current that flows through **each resistor** and **the battery** in the illustrated circuit.



Two resistors, with resistances  $R_1$  and  $R_2$ , are connected to a battery as illustrated. The battery provides potential difference  $\Delta V$ .

a) Derive an expression for the current (in terms of  $R_1, R_2$ and  $\Delta V$ ) that flows through each resistor in the illustrated circuit.



b) Derive an expression for the potential difference (in terms of  $R_1, R_2$  and  $\Delta V$ ) across the resistor with resistance  $R_1$  in the illustrated circuit.

c) Determine the ratio  $R_1/R_2$  such that the potential difference across the resistor with resistance  $R_1$  is one third of the potential difference provided by the battery.

A heater is designed to produce 1200 W of power when connected to a 120 V outlet. Assuming that the heater obeys Ohm's law, determine the resistance of the heater.

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#### Question 8

Two metal rods are connected to a battery as illustrated. The cylinders have the same lengths and also the same radius. The resistivity of rod A is five times that of rod B. Which of the following (choose one) is true regarding the currents through the rods?

- i)  $I_{\text{in A}} = I_{\text{in B}}$
- ii)  $I_{\text{in A}} = 25 I_{\text{in B}}$
- iii)  $I_{\text{in A}} = 5 I_{\text{in B}}$
- iv)  $I_{\text{in A}} = \frac{1}{5} I_{\text{in B}}$

#### Question 9

Three identical resistors are connected to a battery as illustrated in the following circuit. Which of the following (choose one) is the equivalent resistance of the portion of the circuit within the box?

- i)  $R_{\rm eq} = R/3$
- ii)  $R_{\rm eq} = R/2$
- iii)  $R_{\rm eq} = R$
- iv)  $R_{\rm eq} = 2R$
- v)  $R_{\rm eq} = 3R$







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