NAME: ____________________________

I. **Review of charging and discharging a capacitor (refer to Chapter 26).**
Consider a series circuit containing a resistor of resistance $R$ and a capacitor of capacitance $C$ connected to a source of EMF $\mathcal{E}$ with negligible internal resistance. The wires are also assumed to have zero resistance. Initially, the switch is open and the capacitor discharged.

1. **Immediately after the switch is closed**, check one box for each column:

<table>
<thead>
<tr>
<th>Voltage across capacitor</th>
<th>Voltage across resistor</th>
<th>Current magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_C = \mathcal{E}$</td>
<td>$V_R = \mathcal{E}$</td>
<td>$I_{\text{initial}} = \frac{\mathcal{E}}{R}$</td>
</tr>
<tr>
<td>$V_C = \mathcal{E}/2$</td>
<td>$V_R = \mathcal{E}/2$</td>
<td>$I_{\text{initial}} = 0$</td>
</tr>
<tr>
<td>$V_C = 0$</td>
<td>$V_R = 0$</td>
<td></td>
</tr>
</tbody>
</table>

2. Eventually, the process approaches a **steady state**. In that **steady state**, the charge of the capacitor is not changing. In the **steady state**, check one box for each column.

<table>
<thead>
<tr>
<th>Circuit current $I_{\text{fin}}$</th>
<th>Charge on capacitor $Q_{\text{fin}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{\text{fin}} = \mathcal{E}/(R+C)$</td>
<td>$Q_{\text{fin}} = C\mathcal{E}$</td>
</tr>
<tr>
<td>$I_{\text{fin}} = 0$</td>
<td>$Q_{\text{fin}} = C\mathcal{E}/R$</td>
</tr>
<tr>
<td>$I_{\text{fin}} = \mathcal{E}/R$</td>
<td>$Q_{\text{fin}} = 0$</td>
</tr>
</tbody>
</table>

3. Which of the following are correct expressions for charge on the capacitor and current in this circuit as a function of time? (choose one from each column). Remember switch closed at $t=0$.

- $q = Q_{\text{max}} e^{-t/RC}$
- $q = Q_{\text{max}} (1 - e^{-t/RC})$
- $i = I_{\text{max}} (1 - e^{-t/RC})$
- $i = -I_{\text{max}} e^{-t/RC}$
- $i = -I_{\text{max}} (e^{-t/RC})$

4. Sketch rough plots of $q$ vs. time and $i$ vs. time to support your choices. Indicate the values of $q$ and $i$ at $t = 0$ and $t \gg RC$ on the plot. Indicate on the y axes the values of $Q_{\text{max}}$ and $I_{\text{max}}$, respectively.
II. Inductors in DC circuits
Consider a series circuit containing a resistor of resistance $R$ and an inductor of inductance $L$ connected to a source of EMF $\varepsilon$ with negligible internal resistance. The wires are also assumed to have zero resistance. Initially, the switch has been open for a long time.

1. \textit{Immediately after the switch is closed}, check one box for each column.

\begin{center}
\begin{tabular}{ccc}
\textbf{Voltage across inductor} & \textbf{Voltage across resistor} & \textbf{Circuit Current $I_{\text{initial}}$} \\
\hline
\checkmark V_L=\varepsilon & \checkmark V_R=\varepsilon & \checkmark I_{\text{initial}}=\varepsilon/R \\
\checkmark V_L=\varepsilon/2 & \checkmark V_R=\varepsilon/2 & \checkmark I_{\text{initial}}=0 \\
\checkmark V_L=0 & \checkmark V_R=0 & \\
\end{tabular}
\end{center}

2. Eventually, the process approaches a \textit{steady state}. In that \textit{steady state}, the current approaches its maximum value and its derivative approaches zero. In the \textit{steady state}, check one box for each column.

\begin{center}
\begin{tabular}{ccc}
\textbf{Voltage across inductor} & \textbf{Voltage across resistor} & \textbf{Circuit current $I_{\text{fin}}$} \\
\hline
\checkmark V_L=\varepsilon & \checkmark V_R=\varepsilon & \checkmark I_{\text{fin}}=\varepsilon/(R+L) \\
\checkmark V_L=\varepsilon/2 & \checkmark V_R=\varepsilon/2 & \checkmark I_{\text{fin}}=0 \\
\checkmark V_L=0 & \checkmark V_R=0 & \checkmark I_{\text{fin}}=\varepsilon/R \\
\end{tabular}
\end{center}

3. Which of the following are correct expressions for voltage across the inductor and current in the circuit as a function of time? (choose one from each column). Remember switch closed at $t=0$.

\begin{center}
\begin{tabular}{ll}
\checkmark V_L=\varepsilon \left(e^{-\frac{Rt}{L}}\right) & \checkmark i=I_{\text{max}} \left(1-e^{-\frac{Rt}{L}}\right) \\
\checkmark V_L=\varepsilon \left(1-e^{-\frac{Rt}{L}}\right) & \checkmark i=I_{\text{max}} e^{-\frac{Rt}{L}} \\
\end{tabular}
\end{center}

4. Sketch rough plots of $V_L$ vs. time and $i$ vs. time to support your choices. Indicate the values of $V_L$ and $I$ at $t=0$ and $t \gg L/R$ on the plot. Indicate on the $y$ axes the values of $\varepsilon$ and $I_{\text{max}}$, respectively.