Show all your work. Write your answers in the blanks provided.

(8 pts) 1. Calculate the binding energy (in MeV) of the nucleus $^7_3\text{Li}$. Note that Table 30.2 from the textbook is included on the formula sheet.

    Ans. ____________

(10 pts) 2. A photon of wavelength 0.0940 nm strikes a free electron that is initially at rest and the photon is scattered backwards, at an angle of 180° from its original direction.

a) What is the energy of the photon after it scatters from the electron?  Ans. ______________

b) What is the deBroglie wavelength of the electron immediately after its collision with the photon?  Ans. ______________
(10 pts) 3. The surface of a flat piece of glass is covered by a thin plastic film that has thickness 180 nm. There is air above the plastic film. The refractive index of the glass is 1.40 and the refractive index of the plastic film is 1.80. Light of wavelength $\lambda_{air}$ in air shines at normal incidence on the plastic film. What is the largest value of $\lambda_{air}$ for which there will be constructive interference between the light reflected at the top and bottom surfaces of the film?

\[ \text{Ans. } \]

(10 pts) 4. An object with height 4.00 mm is to the left of a converging thin lens that has focal length 9.00 cm. The image formed by the lens is 1.30 cm tall and is upright.

a) Is the image real or virtual?

\[ \text{Ans. } \]

b) Is the image to the left or to the right of the lens?

\[ \text{Ans. } \]

c) How far is the object from the lens?

\[ \text{Ans. } \]
(15 pts) 5. 

a) A long straight wire carries current that is to the right. A small sphere with negative charge is moving parallel to the wire, in the same direction as the current. What is the direction of the force that the wire exerts on the sphere (toward top of page, toward bottom of page, to the left, to the right, into the page, or out of the page)?

\[ \rightarrow \quad \checkmark \]

Ans. ______________

b) A long straight wire carries current toward the top of the page, as shown in the sketch. The wire is in a uniform magnetic field that is directed into the page. What is the direction of the force that the magnetic field exerts on the wire (toward top of page, toward bottom of page, to the left, to the right, into the page, or out of the page)?

\[ x \quad x \quad x \]

\[ x \quad \uparrow \quad \downarrow \quad I \]

\[ x \quad x \]

Ans. ______________

c) A long straight wire carries current toward the left. This current is increasing in magnitude at a constant rate. A small square loop of wire is at rest above the wire, as shown in the sketch. What is the direction of the current induced in the loop (clockwise or counterclockwise) or is the current in the loop zero (no induced current)?

\[ \leftarrow \]

Ans. ______________

d) A metal bar is moving to the right, as shown in the sketch. The bar is in a uniform magnetic field \( \vec{B} \) that is directed out of the page. Which end of the bar, \( a \) or \( b \), is at higher potential?

Ans. ______________

e) A rectangular loop of wire is being pulled to the right out of a region of uniform magnetic field that is directed into the page. As the loop is being pulled from the field region, what is the direction of the current induced in the loop (clockwise or counterclockwise) or is the current in the loop zero (no induced current)?

Ans. ______________
(9 pts) 6. A conducting bar with length 0.0600 m slides toward the left without friction on conducting metal rails, as shown in the sketch. The apparatus is in a uniform magnetic field \( B = 2.00 \, \text{T} \) that is directed perpendicular to the page in the sketch. The resistance of the circuit is a constant \( 5.00 \, \Omega \). The induced current in the circuit (bar, rails, resistor) is clockwise.

![Diagram of a circuit with a bar moving through a magnetic field]

a) Is the 2.00 T magnetic field directed into the page or out of the page?

Ans. __________

b) What is the speed \( v \) of the bar at the instant when the resistor is dissipating electrical energy at a rate of 1.20 J/s?

Ans. __________

c) When the bar has the speed calculated in part (b), what is the magnitude of the force that the magnetic field exerts on the bar?

Ans. __________
(9 pts) 7. In a L-R-C series circuit, the magnitude of the phase angle is 54.0°, with the source voltage lagging the current. The reactance of the capacitor is 400 Ω and the resistance of the resistor is 200 Ω. The average power delivered by the source is 150 W.

a) What is the reactance of the inductor? Ans. 

b) What is the current amplitude in the circuit? Ans. 

c) What is the voltage amplitude of the source? Ans. 


(10 pts) 8. Three resistors are connected to a battery as shown in the sketch. The battery has negligible internal resistance. \( R_1 = 3.00 \, \Omega \), \( R_2 = 6.00 \, \Omega \) and \( R_3 = 5.00 \, \Omega \). The current through resistor \( R_2 \) is 4.00 A.

\[ \text{\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{resistor_diagram.png}
\end{figure}} \]

a) What is the current \( I_1 \) through resistor \( R_1 \)? Ans. 

b) What is the current \( I_3 \) through resistor \( R_3 \)? Ans. 

c) What is the emf of the battery? Ans.
(10 pts) 9. A negative point charge \( q_1 = -3.00 \times 10^{-9} \, \text{C} \) is located on the \(-x\)-axis at \( x = -0.400 \, \text{m} \). A positive point charge \( q_2 = +5.00 \times 10^{-9} \, \text{C} \) is located on the \(+x\)-axis at \( x = +0.600 \, \text{m} \). What are the magnitude and direction (\(+x\) or \(-x\)) of the resultant electric field at the origin that is produced by these two charges?

Ans. direction ________________

\[ E = \]
(9 pts) 10. A small object with charge $q_1 = -2.00 \times 10^{-6} \text{ C}$ is held fixed at the origin. A second small object with charge $q_2 = +5.00 \times 10^{-6} \text{ C}$ is held fixed on the $+x$-axis at $x = 2.00 \text{ m}$. Point $a$ is on the $+x$-axis at $x = 0.500 \text{ m}$ and point $b$ is on the $+x$-axis at $x = 1.50 \text{ m}$. A small sphere with negative charge $q_3 = -5.00 \times 10^{-4} \text{ C}$ and mass $12.0 \times 10^{-3} \text{ kg}$ is released from rest at point $a$ and it then moves in the $+x$-direction, toward $q_2$. What is the speed of the sphere when it reaches point $b$?

Ans. ____________