**PHYS305** **Exam 3** **Name**

Key

**Problem 1**: Consider the following nuclear reaction: 17 points

$$^{238}U + n \rightarrow {}^{A}X$$

where $^{A}X$ is some unknown element, X, of atomic mass, A.

a. What is this reaction element?

(Uranium has an atomic number of Z=92 (See Periodic Table). A neutron has an atomic number of Z=0, but atomic mass of A=1)

$$^{238}_{92}U + ^{1}_{0}n \rightarrow ^{A}_{Z}X$$

$238 + 1 = A \Rightarrow A = 239$

$92 + 0 = Z \Rightarrow Z = 92$

So $^{A}_{Z}X = {}^{239}U$

(9)

b. Consider if the reaction emitted an electron:

$$^{238}U + n \rightarrow {}^{A}X + e$$

What is this reaction element?

$$^{238}_{92}U + ^{1}_{0}n \rightarrow ^{A}_{Z}X + ^{0}_{-1}e$$

(8)

$238 + 1 = A + 0 \Rightarrow A = 239$

$92 + 0 = Z - 1 \Rightarrow Z = 92 + 1 = 93$

So $^{A}_{Z}X = {}^{239}Np$

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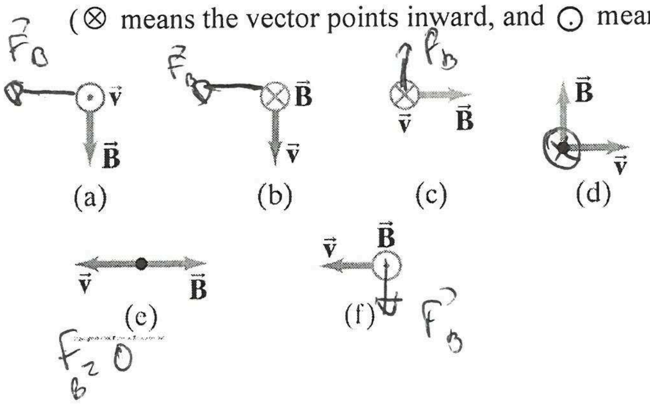
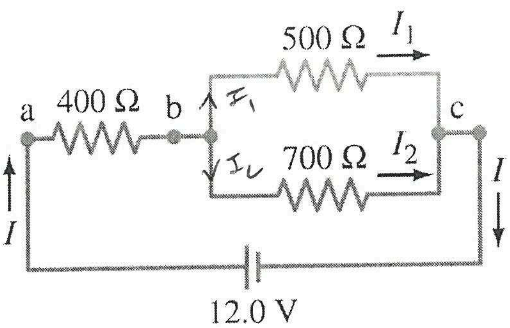
**Problem 2 (16 points):** Find the direction of the force on a negative charge for each diagram shown in Fig. below, where $\vec{\mathbf{v}}$ (green) is the velocity of the charge and $\vec{\mathbf{B}}$ (blue) is the direction of the magnetic field.

(⊗ means the vector points inward, and ⊙ means it points outward, toward you.)




$\vec{F}_B = q(\vec{v} \times \vec{B})$

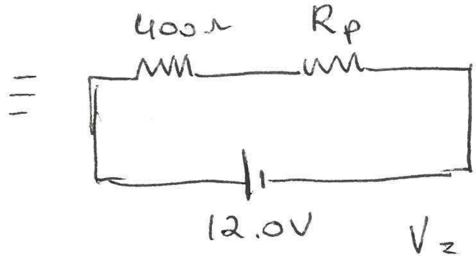
**Problem 3:** How much current is drawn from the battery shown? What is the current through the 500-Ω resistor shown?




* calculate the Req of 500 Ω & 700 Ω

$$\frac{1}{R_p} = \frac{1}{500\,\Omega} + \frac{1}{700\,\Omega} = 0.0034\,\Omega^{-1}$$ (3)

$\Rightarrow R_p = 290\,\Omega$




$R_{eq} = R_p + R_{400} = 290\,\Omega + 400\,\Omega$
$= 690\,\Omega$ (3)

$V = R_{eq} I \Rightarrow I = \frac{V}{R_{eq}} = \frac{12.0\,V}{690\,\Omega} = 0.0174\,A$ (3)

* current through the 500 Ω

$I = I_1 + I_2$ (3)

$V_{500\,\Omega} = V_{700\,\Omega}$

$V_{ab} = R_{400} I = (400\,\Omega)(0.0174\,A) = 7.0\,V$

$V_{ac} = V_{ab} + V_{bc} = V_{400} + V_{500} \Rightarrow V_{500} = V_{ac} - V_{bc}$ (3)

$\Rightarrow V_{500} = 12\,V - 7.0\,V = 5.0\,V$

So $I_1 = \frac{V_{500}}{500\,\Omega} = \frac{5.0\,V}{500\,\Omega} = 1.0 \times 10^{-2}\,A = 10\,mA$ (2)

$I_2 = \frac{V_{700}}{700\,\Omega} = \frac{5.0\,V}{700\,\Omega} = 7 \times 10^{-3}\,A = 7.0\,mA$

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**Problem 4:** A long wire stretches along the x axis and carries a 3.0-A current to the right (+x). The wire is in a uniform magnetic field $\vec{B} = (0.20\hat{\imath} - 0.36\hat{\jmath} + 0.25\hat{k})\ T$. Determine the components of the force on the wire per cm of length.

$$\vec{F} = I \vec{l} \times \vec{B}$$

$$\vec{F} = 3.0A \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 0 & 0 \\ 0.20 & -0.36 & 0.25 \end{vmatrix} = 3.0A\left[\hat{i}(0-0) - \hat{j}(0.25) + \hat{k}(-0.36)\right]$$

$$= (-0.75\hat{j} - 1.08\hat{k})\frac{N}{m} \times \frac{1m}{100cm}$$

$$= (-7.5\hat{j} + 10.8\hat{k}) \times 10^{-3} N/cm$$

**Problem 5:** Most consumer electronic devices that plug into a 110V wall socket (computers, home theater, alarm clocks, even clocks on ovens) require an internal transformer to convert that 110V into 9V for the actual electronic components that run the device. What's the turns ratio on such a transformer and what is the current ratio (secondary current divided by primary current)?

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{9V}{110V} = 0.082$$

$$\frac{I_s}{I_p} = \frac{N_p}{N_s} \quad \& \quad \frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$\Rightarrow \frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{110V}{9V} = 12.2$$

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**Problem 6:** Fill in the missing atom (nucleus) , X, for each potential fusion reaction:

(a) D + D → p + X + 3.3MeV

(b) D + D → n + X + 4.0MeV

(c) D + T → n + X + 17.6MeV

(d) D + 3He → p + X + 18.3MeV

(a) ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{1}_{1}H + {}^{A}_{Z}X + Q$

$2+2 = 1+A \Rightarrow A = 3$
$1+1 = 1+Z \Rightarrow Z = 1$
$\Rightarrow X = {}^{3}_{1}H = T$ = Triton

(b) ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{1}_{0}n + {}^{A}_{Z}X + Q$

$2+2 = A+1 \Rightarrow A = 3$
$1+1 = 0+Z \Rightarrow Z = 2$
$\Rightarrow X = {}^{3}_{2}He$

(c) ${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{1}_{0}n + {}^{A}_{Z}X + Q$

$2+3 = 1+A \Rightarrow A = 4$
$1+1 = 0+Z \Rightarrow Z = 2$
$\Rightarrow X = {}^{4}_{2}He$ alpha particle

(d) ${}^{2}_{1}H + {}^{3}_{1}He \rightarrow {}^{1}_{1}p + {}^{A}_{Z}X + Q$

$2+3 = 1+A \Rightarrow A = 4$
$1+1 = 1+Z \Rightarrow Z = 2$
$\Rightarrow X = {}^{4}_{1}He$ alpha particle

$-1\ 3\ {}^{4}_{2}H$ ⟶ or ${}^{13}C$