## Physics 30: Chapter 4 Exam - Magnetism

Name: _________________________  Date: _____________  Mark: _____/26

### Numeric Response

Place your answers to the numeric response questions, with units, in the blanks at the side of the page. (1 mark each)

1. A proton travelling at $5.3 \times 10^6$ m/s east when it enters a region of uniform magnetic field of $1.0 \times 10^{-2}$ T that is directed upwards from the ground. Determine the magnitude of the force that acts on this proton.

   \[ F_m = q v B \]
   \[ F_m = 1.6 \times 10^{-19} \times 3 \times 10^6 \times 0.01 \]
   \[ F_m = 8.8 \times 10^{-15} \text{ N} \]

   Answer: $8.5 \times 10^{-15}$ N

2. A beam of protons is not deflected as it passes through a velocity selector having a magnetic field strength $2.10 \times 10^{-3}$ T perpendicular to an electric field of 600 N/C. Determine the speed of the protons.

   Answer: $3.00 \times 10^5$ N

3. An alpha particle enters a 1.10 T magnetic field, causing it to turn with a radius of 2.14 cm. Determine the speed of the alpha particle as it enters the magnetic field.

   Answer: $1.13 \times 10^6$ N

4. A 40 cm long copper wire has a mass of 20 g and is carrying a current of 4.5 A at right angles to a uniform magnetic field. This apparatus is placed in a strong magnetic field and the wire is found to levitate. Calculate the magnetic field strength.

   Answer: 0.11 T
Written Response. Show all your work. Clearly identify your final answer(s) rounded off to the proper number of significant digits.

Various hydrocarbons, as listed in the table below, are ionized so they may be identified in a mass spectrometer using their charge-to-mass ratio.

<table>
<thead>
<tr>
<th>Ion</th>
<th>Formula</th>
<th>q/m (x 10^6 C/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>CH_4^+</td>
<td>5.99</td>
</tr>
<tr>
<td>Ethane</td>
<td>C_2H_6^{2+}</td>
<td>6.42</td>
</tr>
<tr>
<td>Propane</td>
<td>C_3H_8^+</td>
<td>2.18</td>
</tr>
<tr>
<td>Butane</td>
<td>C_4H_{10}^{2+}</td>
<td>3.31</td>
</tr>
<tr>
<td>Pentane</td>
<td>C_5H_{12}^+</td>
<td>1.34</td>
</tr>
</tbody>
</table>

A beam of hydrocarbon ions are accelerated across a potential difference of 1616 V and then passed perpendicularly through a magnetic field of 0.25 T. This results in a radius of curvature of 12.5 cm. Determine the identity of the ions using the provided chart and the ion’s charge-to-mass ratio. (5 marks)

\[
\begin{align*}
E_k &= E_p = \frac{1}{2}mv^2 = \frac{1}{2}mv_0^2 = V_q \\
qBv &= m_0v_0^2 \\
v &= \sqrt{\frac{2V_q}{m}} \\
qB &= \frac{q r B}{m} \\
\frac{2V_q}{m} &= \frac{q^2 r^2 B^2}{m} \\
2v &= \frac{q r^2 B^2}{m} \\
\frac{q}{m} &= 3.31 \times 10^6 C/kg
\end{align*}
\]

The ions are butane.
Multiple Choice: Select the best answer. Mark it clearly on your Scantron. (1 mark each)

1. Identify the diagram that best represents magnetic field lines around a bar magnet.

   a. 
   b. 
   c. 
   d. 

Use the information below to answer question 2.

A horizontal wire’s current (electron flow) is to the right as shown in the diagram below.

2. Determine the direction of the magnetic field on a point that is directly beneath of the wire at point Q.
   a. To the left side of the page
   b. To the right side of the page
   c. Out of the page
   d. Into the page

3. Two wires are placed parallel to each other. Wire 1 carries a current of 1.0 A while wire 2 carries a current of 2.0 A. The magnitude of the magnetic force acting on wire 1 is
   a. half as great as the force acting on wire 2
   b. twice as great as the force acting on wire 2
   c. four times as great as the force acting on wire 2
   d. equal to the force acting on wire 2
Use the information below to answer question 4.

The diagram on the right shows a compass needle pointing towards an electromagnet. (The dark end of the compass needle is its north end.) A battery is inserted between C and D to cause the compass needle to point as indicated.

4. Identify the polarity of the electromagnet and the electric polarity of the battery that powers the electromagnet. A is _______, B is _______, C is _______, and D is _________.
   a. north, south, positive, negative
   b. north, south, negative, positive
   c. south, north, positive, negative
   d. south, north, negative, positive

5. A beam of alpha particles are travelling north when they enter a magnetic field directed upwards from the ground. Determine the direction the beam is initially deflected due to the magnetic force acting on it.
   a. east
   b. west
   c. upwards
   d. downward

6. A proton moves across a field of magnetic induction of 0.36 T. It follows a circular path of radius of 0.20 m. The proton’s speed is
   a. \(6.9 \times 10^6\) m/s
   b. \(9.6 \times 10^2\) m/s
   c. \(6.9 \times 10^5\) m/s
   d. \(6.9 \times 10^3\) m/s

7. Electrons move through a field of magnetic induction of \(6.0 \times 10^{-2}\) T. An electric field of 300 N/C prevents the electrons from being deflected. The electron’s speed is
   a. \(6.9 \times 10^2\) m/s
   b. \(5.0 \times 10^3\) m/s
   c. \(5.0 \times 10^5\) m/s
   d. \(6.9 \times 10^3\) m/s

8. Identify the fields that are capable of exerting a force on a beam of electrons.
   a. Electric fields only
   b. Magnetic fields only
   c. Magnetic and electric fields only
   d. Electric, gravitational, and magnetic fields
Use the following information to answer question 9.

An electron approaches an electric field and a magnetic field as shown in the two diagrams below.

9. Which best describes the direction the electron travels through each field?

<table>
<thead>
<tr>
<th>Electric Field</th>
<th>Magnetic Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. up</td>
<td>down</td>
</tr>
<tr>
<td>b. up</td>
<td>up</td>
</tr>
<tr>
<td>c. down</td>
<td>into page</td>
</tr>
<tr>
<td>d. down</td>
<td>out of page</td>
</tr>
</tbody>
</table>

Use the following information to answer question 10.

A conducting rod is moved along two parallel wires that are in a magnetic field as shown in the circuit diagram below. The magnetic field is directed out of the page.

10. The direction of the conventional current through the circuit is
    a. counter clockwise
    b. down
    c. up
    d. clockwise

11. Identify the units below that are not equivalent to the unit of tesla.
    a. kg/s²*A
    b. N*s/C*m
    c. N/m*s*C
    d. N/m*A
Use the diagram below to answer question 12.

![Diagram of a coil with magnetic field directions](image)

12. The direction of electron flow through the galvanometer is
   a. from left to right  b. up  
   c. from right to left  d. down

Use the information below to answer questions 13 – 15.

The ions in a mass spectrometer are given kinetic energy by crossing a potential difference (V). They then pass through a magnetic field (B) perpendicular to their direction of travel. This results in a centripetal acceleration causing them to curve with a radius r.

13. Select the graph that correctly shows the relationship between the radius of the ion’s path and the magnetic field strength.
   a. ![Graph A](image)  b. ![Graph B](image)
   c. ![Graph C](image)  d. ![Graph D](image)

14. You would get a straight line if you placed “r” on the y-axis and
   a. B on the x-axis  b. \( \frac{1}{B} \) on the x-axis  
   c. \( \frac{1}{B^2} \) on the x-axis  d. \( B^2 \) on the x-axis

15. The slope of the graph of the straight line from the previous question is
   a. \( \frac{qv}{m} \)  c. \( \frac{vj}{m} \)
   b. \( \frac{mv}{q} \)  d. \( \frac{qm}{v} \)
Four charged particles enter a magnetic field in a bubble chamber. Their paths through the bubble chamber are shown in the diagram below. Each particle enters the field with the same velocity and magnitude of charge. The magnitude of the orbital radius, from largest to smallest is A, D, B, and C.

16. The negatively charged ions are both
   a. A and C
   b. C and B
   c. A and B
   d. C and D

17. Ranks the ions from largest mass to smallest mass.
   a. A, B, C, D
   b. D, C, B, A
   c. C, B, D, A
   d. A, D, B, C
MC average: 66%

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>% Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td>72</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>88</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>A</td>
<td>92</td>
</tr>
<tr>
<td>7</td>
<td>B</td>
<td>80</td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>32</td>
</tr>
<tr>
<td>9</td>
<td>C</td>
<td>68</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>% Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>D</td>
<td>32</td>
</tr>
<tr>
<td>11</td>
<td>C</td>
<td>24</td>
</tr>
<tr>
<td>12</td>
<td>C</td>
<td>40</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
<td>68</td>
</tr>
<tr>
<td>14</td>
<td>B</td>
<td>84</td>
</tr>
<tr>
<td>15</td>
<td>B</td>
<td>84</td>
</tr>
<tr>
<td>16</td>
<td>D</td>
<td>76</td>
</tr>
<tr>
<td>17</td>
<td>D</td>
<td>64</td>
</tr>
</tbody>
</table>