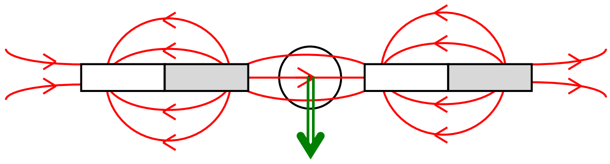
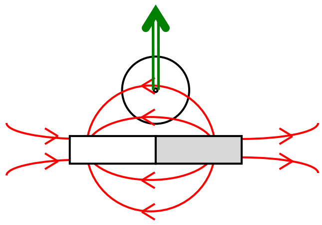
Electric charges moving in a magnetic field

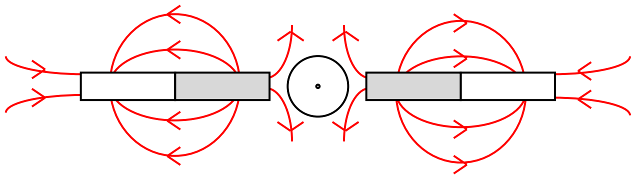
1. a)



b)



c)

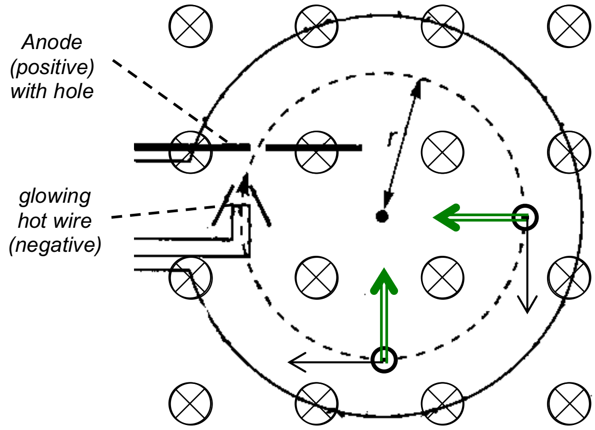


magnetic force: 

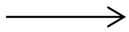
no magnetic field → no magnetic force

2. a) clockwise

b) and c)



Direction of motion of the electrons:



magnetic force:

3. a) $E_{kin} = W_{accelerating} = q \cdot U = 1\ \text{e} \cdot 210\ \text{V} = \underline{210\ \text{eV}} = 1.6 \cdot 10^{-19}\ \text{C} \cdot 210\ \text{V} = \underline{3.36 \cdot 10^{-17}\ \text{J}}$

b) $$v = \sqrt{\frac{2 \cdot E_{kin}}{m}} = \sqrt{\frac{2 \cdot q \cdot U}{m}} = \sqrt{\frac{2 \cdot 1.6 \cdot 10^{-19}\ \text{C} \cdot 210\ \text{V}}{9.11 \cdot 10^{-31}\ \text{kg}}} = \underline{\underline{8.59 \cdot 10^{6}\ \frac{\text{m}}{\text{s}}}}$$

c) $$B = \frac{m \cdot v}{q \cdot r} = \frac{9.11 \cdot 10^{-31}\ \text{kg} \cdot 8.59 \cdot 10^{6}\ \frac{\text{m}}{\text{s}}}{1.6 \cdot 10^{-19}\ \text{C} \cdot 0.040\ \text{m}} = 0.0012\ \text{T} = \underline{\underline{1.22\ \text{mT}}}$$

4. a) $v = \sqrt{\dfrac{2 \cdot E_{kin}}{m}} = \sqrt{\dfrac{2 \cdot q \cdot U}{m}} = \sqrt{\dfrac{2 \cdot 1.6 \cdot 10^{-19}\ \text{C} \cdot 200\ \text{V}}{9.11 \cdot 10^{-31}\ \text{kg}}} = \underline{\underline{8.38 \cdot 10^6\ \dfrac{\text{m}}{\text{s}}}}$

b) $r = \dfrac{m \cdot v}{q \cdot B} = \dfrac{9.11 \cdot 10^{-31}\ \text{kg} \cdot 8.38 \cdot 10^6\ \frac{\text{m}}{\text{s}}}{1.6 \cdot 10^{-19}\ \text{C} \cdot 4.0 \cdot 10^{-5}\ \text{T}} = \underline{\underline{1.19\ \text{m}}}$

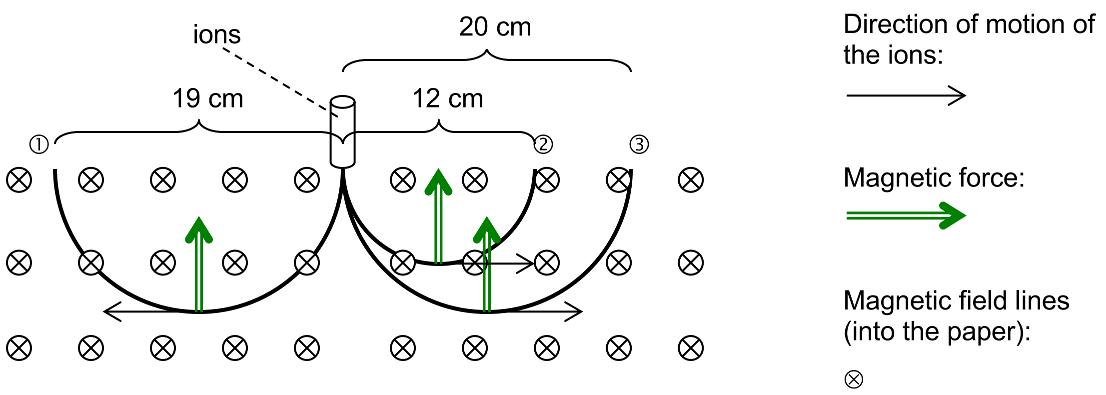
c) $s = 2\pi \cdot r$ $\quad t = \dfrac{s}{v} = \dfrac{2\pi \cdot r}{v} = \dfrac{2\pi \cdot 1.19\ \text{m}}{8.39 \cdot 10^6\ \frac{\text{m}}{\text{s}}} = \underline{\underline{8.93 \cdot 10^{-7}\ \text{s}}}$

5. From $E_{\text{kin}} = W_{\text{accelerating}}$ $\quad \dfrac{1}{2} \cdot m \cdot v^2 = q \cdot U \quad \Rightarrow \quad v^2 = \dfrac{2 \cdot q \cdot U}{m}$

and $F_{\text{centripetal}} = F_{\text{magnetic}}$ $\quad m \cdot \dfrac{v^2}{r} = q \cdot v \cdot B \quad \Rightarrow \quad v = \dfrac{q \cdot B \cdot r}{m}$

we get $v^2 = \dfrac{q^2 \cdot B^2 \cdot r^2}{m^2} = \dfrac{2 \cdot q \cdot U}{m}$ solving for $\dfrac{q}{m}$ yields $\underline{\underline{\dfrac{q}{m} = \dfrac{2 \cdot U}{r^2 \cdot B^2}}}$

6. a) $F_{\text{centripetal}}$ acts towards the center of the circular path (see picture). Use the "left-hand-rule" for negative charges and the "right-hand-rule" for positive charges.
Therefore, <u>① negative, ② and ③ positive</u>



b) r is inversely proportional to q. Therefore, if the mass is approximately the same, while the radius of one particle is half of the other one, the charge of ion ② (half the radius) must be double the charge of ion ①.
→ <u>ion ②</u>

c) ①: $m = \dfrac{q \cdot B \cdot r}{v} = \dfrac{1.6 \cdot 10^{-19}\ \text{C} \cdot 0.208\ \text{T} \cdot 0.095\ \text{m}}{1.0 \cdot 10^5\ \frac{\text{m}}{\text{s}}} = \underline{\underline{3.16 \cdot 10^{-26}\ \text{kg}}}$ (fluorine)

②: $m = \underline{3.99 \cdot 10^{-26}\ \text{kg}}$ (magnesium)

③: $m = \underline{3.32 \cdot 10^{-26}\ \text{kg}}$ (neon)

7. a) $$m_1 = \frac{q \cdot B \cdot r}{v} = \frac{1.602 \cdot 10^{-19}\ \text{C} \cdot 0.300\ \text{T} \cdot 0.1208\ \text{m}}{1.00 \cdot 10^{5}\ \frac{\text{m}}{\text{s}}} = \underline{\underline{5.806 \cdot 10^{-26}\ \text{kg}}}$$

$$m_2 = \frac{q \cdot B \cdot r}{v} = \frac{1.602 \cdot 10^{-19}\ \text{C} \cdot 0.300\ \text{T} \cdot 0.1277\ \text{m}}{1.00 \cdot 10^{5}\ \frac{\text{m}}{\text{s}}} = \underline{\underline{6.137 \cdot 10^{-26}\ \text{kg}}}$$

b) $$m_1 = \frac{5.806 \cdot 10^{-26}\ \text{kg}}{1.6606 \cdot 10^{-27}\ \frac{\text{kg}}{\text{u}}} = 34.96\ \text{u} \cong \underline{\underline{35\ \text{u}}}$$

$$m_2 = \frac{6.137 \cdot 10^{-26}\ \text{kg}}{1.6606 \cdot 10^{-27}\ \frac{\text{kg}}{\text{u}}} = 36.96\ \text{u} \cong \underline{\underline{37\ \text{u}}}$$

c) There are two "kinds" of chlorine atoms (isotopes).
Some of the chlorine atoms have 35 nucleons – 17 protons = 18 neutrons.
The other ones have 37 nucleons – 17 protons = 20 neutrons.