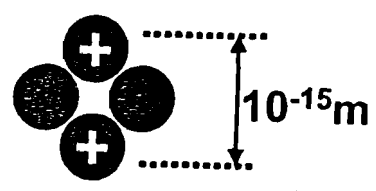


1. The nucleus of a helium atom contains two protons that are typically about $10^{-15}m$ apart. Since protons have the same charge, the electrical force between them is repulsive. The gravitational force between them is attractive. The proton mass is $m_p = 1.7 \times 10^{-27} \text{ kg}$ and its electric charge is $q_p = +1.6 \times 10^{-19} \text{ C}$. (The helium nucleus also contains two particles called neutrons, but since they have no electric charge, you can ignore them for now.)

a) What is the *repulsive* electrical force *Coulomb force* = F_c between the two protons in the helium atom?

$$F_c = \frac{kq_p q_p}{d^2} = 9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2} \frac{(1.6 \times 10^{-19} \text{ C})^2}{(10^{-15} \text{ m})^2} = 230 \text{ N}$$



Helium nucleus
 ⊕ proton
 ● neutron
 (no charge)

b) What is the *attractive* gravitational *Gravity force* = F_N force between the two protons?

$$F_N = G \frac{m_p m_p}{d^2} = 6.7 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2} \frac{(1.7 \times 10^{-27} \text{ kg})^2}{(10^{-15} \text{ m})^2} = 1.9 \times 10^{-34} \text{ N}$$

c) Is the attraction provided by the gravitational force sufficient to counteract the repulsion of the electrical force?

No! The electrical force is more than 10^{36} x bigger than gravity.

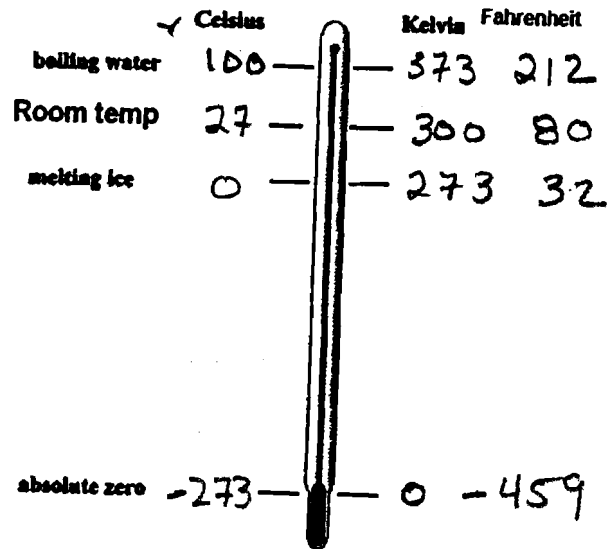
2. Emmy Noether proved that every symmetry of a physical law implied a conservation law and vice versa. In the left-hand column below are listed three quantities that are conserved according to Newton's laws of motion; in the right-hand column are three symmetry properties of Newton's laws. Indicate which symmetries go with which conservation laws.

A) Conserved quantity	(answer)	B) Symmetry
a) Energy	<u>3</u>	1. Same laws apply everywhere
b) Momentum	<u>1</u>	2. All directions are equivalent
c) Angular momentum	<u>2</u>	3. Laws are constant in time

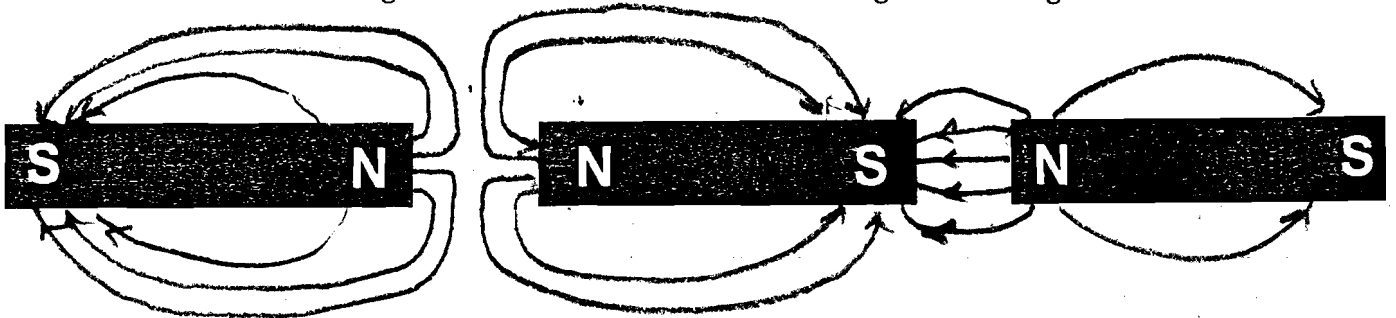
3. List some differences between gravitational, electrical and magnetic forces.

- Gravity is always attractive; Electrical & Magnetic force can be attractive or repulsive.
- Gravity depends on mass; Electrical forces depend on charge
- On a subatomic level, electrical & magnetic forces are much stronger than gravitational forces.

4. Indicate the numerical values for the C , F , and K scale thermometers for the conditions indicated in the sketch below.



5. Sketch what the magnetic field lines look like for the arrangement of magnets shown below.



6. The arrangement of charges sketched at the right produce the pattern of \vec{E} -field lines as shown.

- Indicate the sign of each charge i.e. positive (+) or negative (-).
- Which charge is bigger?

negative charge

