TUTORIAL QUESTIONS_ELECTRIC FIELD (ANSWERS)

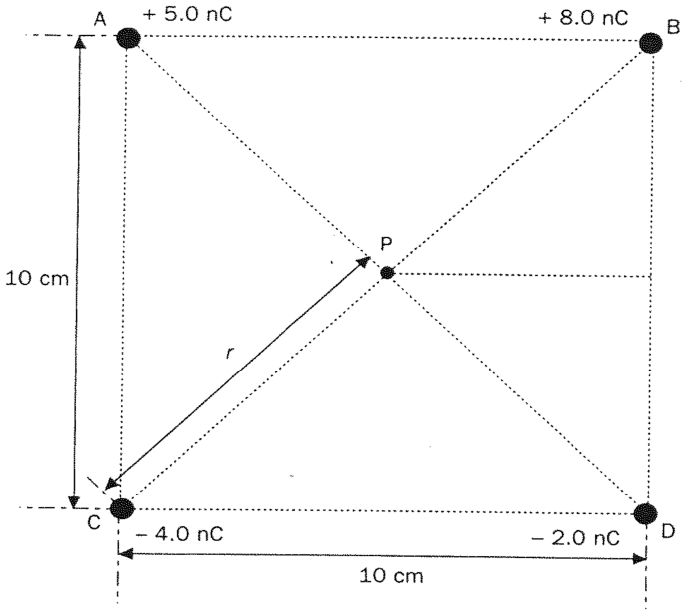
Question 1

Calculate the a.) field strength and b.) the potential at, P midway between 2 small spheres A and B which are 40 cm apart and carry charges of -4.0 nC and -6.0 nC respectively.

(Ans: a.) 450 NC^{-1} b.) -450 JC^{-1})

Question 2

Four charges of +5.0 nC, +8.0 nC, -2.0 nC, and -4.0 nC are positioned at the corners A, B, C, and D of a square of side 10 cm as shown in the diagram below.



Calculate a.) field strength and b.) the potential at the centre (P) of the square.

(Ans: a.) 2.50 x 10^4 NC^{-1} b.) 8.9 x 10^2 JC^{-1})

Question 3

2 parallel, horizontal plates are placed 4.0 cm apart in an evacuated chamber. If the upper plate is kept at a positive potential of 1.0 x 10^4 V relative to the lower plate, calculate:

a.) the strength of the uniform electric field between the plates. **(Ans: 2.5 x 10^5 NC^{-1})**

b.) the speed which an electron acquires if it moves from rest from the positive to the negative plate under the influence of the field. **(Ans: 5.93 x 10^7 ms^{-1})**

Question 4

In a particular experiment, a high voltage is created by charging an isolated metal sphere, as illustrated in Fig. 4.1.

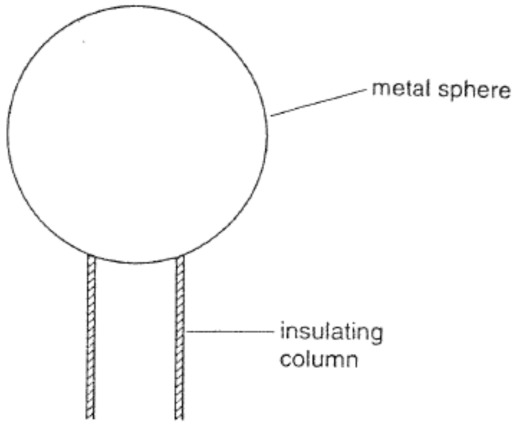


Fig. 4.1

The sphere has diameter 42 cm and any charge on its surface may be **considered as if it were concentrated at its centre.**

The air surrounding the sphere loses its insulating properties, causing a spark, when the electric field exceeds 20 k Vcm^{-1}.

a.) By reference to an atom in the air, suggest the mechanism by which the electric field causes the air to become conducting.

The field will produce electric force whereby if the force is large enough, it can cause the electrons to be stripped off the atom. This force will cause the electrons to move in one direction and the nucleus / positive ion to move in the opposite direction. This movement of the electrons is the reason to why the air becomes conducting.

b.) Calculate, for charged sphere when a spark is about to occur,

i.) the charge on the sphere, by assuming the charge is concentrated at its centre. **(Ans: 9.8 x 10^{-6} C)**

ii.) Its potential. **(ans: 4.2 x 10^{5} V)**

Question 5

Electrons in a cathode ray tube leave the cathode with negligible speed at a potential of -4500 V and are accelerated to an anode at a potential of -100 V. For an electron in this tube, calculate the,

i.) electrical potential and state whether is it a gain or loss. **(Ans: 4400 V, gain potential)**

ii.) electrical potential energy and state whether is it a gain or loss. **(Ans: 7.04 x 10^{-16} J, loss E.P.E)**

iii.) the gain kinetic energy. **(Ans: 7.04 x 10^{-16} J)**

iv.) the speed on reaching the anode. **(Ans: 3.93 x 10^{7} ms^{-1})**

v.) Explain why (i) is a gain but (ii) is a loss.

Electron gains potential because it moves from a lower potential to a higher potential region. Electron is a negative charge. It loses electrical potential energy as the potential rises. System itself will do work to move the electron away from the cathode to the anode, when system do work, system will lose potential energy.

Question 6

a.) The potential in the gravitational field of point mass decreases with decreasing distance from the mass. In the electric field of a point charge, electric potential may increase or decrease with decreasing distance from the charge. Explain this difference.

In gravitational field, the force is always attractive. Therefore, with decreasing distance, system has to do more work in coming closer together.

In electric field, the force can be attractive or repulsive depends on the sign of charges.

b.) The radius of Lithium nucleus is 2.3 x 10^{-15} m, and the radius of a proton is 1.2 x 10^{1-5} m.

i.) Calculate the electric potential energy of a proton when it is just in contact with a lithium nucleus. You may assume that the proton and the lithium nucleus act as point charges. **(Ans: 1.97 x 10^{-13} J)**

ii.) By reference to your answer to (i), suggest why particle accelerators used for research into the composition of nuclei are referred to as 'high energy' accelerators.

In particle accelerators, more energy than 1.97 x 10^{-13} J is actually required to penetrate the nucleus. On a nuclear scale, the energy is large.