Preparation Test

Name:

Part A: Short Questions

Remarks:

- No aids (calculator, FoTa, formula sheet) allowed
- Always express numerical results as rounded decimal numbers (except in ratios)
- Derivation required for numerical results

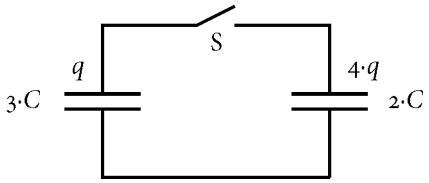
1. On the reverse side of the sheet, sketch the effect of a smoothing capacitor on an alternating voltage signal.
2. Which of the following statements are true?

   ☐ The capacitance a parallel plate capacitor is doubled when the distance between the plates is halved.

   ☐ The potential of a negative point charge is greater close to the charge than far away.

   ☐ A 5 keV electron is described by the laws of classical physics with a very good accuracy.

   ☐ Electric potential energy is to potential as force is to field.
3. What is the charge on the left capacitor after the switch S has been closed? Give reasons for your answer.



4. The energy density increases by 20 % between two points of an electric field. Calculate the percentage change of the magnitude of the electric field between these two points.

5. Draw the line of zero potential in the field of the two point charges (reference level at infinity).

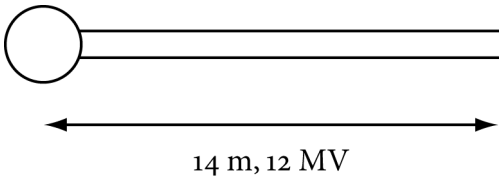
Numerical Solutions: 2. ☑ ☒ ☑ ☑; 3. 2 q (same potential difference); 4. + 10 %

Part B: Problems

Remarks:

- Write you solutions to the problems on the answer sheet. Start a new page for every problem.
- An algebraic solution and all values used in calculations are required to get the full mark.
- Results must be rounded to at most three significant figures.

1. Carbon ions (^{12}C) are accelerated in a Van de Graaff accelerator providing a potential difference of 12 MV.



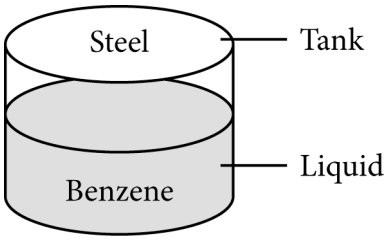
   a) Calculate the kinetic energy (in MeV) and the speed (as a fraction of the speed of light) of a triply charged ion (C^{3+}) leaving the accelerator.

   b) The Van the Graaff accelerator consists of a charged sphere with radius 1.2 m at the beginning of the 14 m long accelerator line. Calculate the charge on the sphere. Is it positive or negative?

   (Hint: The potential outside a charged sphere is the same as that of an equally charged point charge at the centre of the sphere.)

2. A cylindrical tank for liquids consists of two circular steel plates with radius 2.4 m for top and bottom and an insulating wall 3.2 m high. The level of the liquid in the tank is checked by measuring the capacitance between the top and the bottom plate.

   When the tank is completely filled with benzene (*Benzol*), the capacitance is 104 pF.



   a) The potential difference measured between the top and bottom of the full tank is 27 V. Calculate the charge on a plate and the energy stored in the electric field.

   b) Calculate the capacitance of the empty tank and determine the dielectric constant of benzene.

   c) Using the formula for capacitors in series derive the following expression for the capacitance of a partially filled tank:

$$C(x) = C_0 \cdot \frac{\kappa}{\kappa\,(1-x)+x}$$

   In this expression C_0 is the capacitance of the empty tank, κ the dielectric constant and x the fraction of the tank which is filled.

Numerical Solutions: 1. 36 MeV, 0.08 *c*, 1.8 mC; 2. 2.8 nC, 38 nJ, 50 pF, 2.1