1. Define the following terms:

<table>
<thead>
<tr>
<th>Conservation of charge</th>
<th>Electrical force</th>
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<tbody>
<tr>
<td>Coulomb</td>
<td>Test charge</td>
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<tr>
<td>Coulomb’s law</td>
<td>Electric Field Intensity</td>
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</tbody>
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2. Distinguish between the following sets of words.

<table>
<thead>
<tr>
<th>Conductor, Insulator</th>
<th>Positive ion, Negative ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proton, Neutron, Electron</td>
<td>Electrostatics, Electricity</td>
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</table>

3. With the aid of a well labeled diagram, explain how to charge an object using all three different methods.

   (friction, contact, and induction)

4. Explain the differences between gravitational forces and electrostatic forces for the following.
   a) Which forces repel and which forces attract?
   b) How is the direction of an each field determined?
   c) Which quantity causes each field to exist?

5. Using the fact that only electrons can move, explain the following?
   a) why a rubber rod becomes charged when rubbed with fur?
   b) why a glass rod becomes positively charged when rubbed with silk.

6. How is Coulomb’s law similar to Newton’s law of gravitation? How are they different?

7. The proportionality constant in Coulomb’s law is $9 \times 10^9 \text{NmC}^{-2}$ and the proportionality constant in Newton’s universal gravitational law is $6.67 \times 10^{-11} \text{NmC}^{-2}$. What does this mean in terms of the relative strengths of these two forces? (Hint: Think about the four fundamental forces and which are the strongest and which are the weakest.)

8. Why are metals good conductors? Why are glass and rubber good insulators?

9. A positively charged body attracts a suspended cork ball and repels a suspended metal ball. What conclusions can be drawn about the charge present on each ball from these observations?

10. What does it mean to say that an object is electrically polarized?

11. Electrical forces between charges are enormous in comparison to gravitational forces. Yet, we normally don’t sense electrical forces between us and our environment, while we do sense our gravitational interaction with the earth. Why is this so?

12. By how much is the electrical force between a pair of ions reduced when their separation distance is doubled? Tripled?

13. If you scuff electrons from a rug onto your shoes, are you positively or negatively charged? What is the charge on the rug? What type of charging process is this?

14. Explain why the leaves of a neutral leaf electroscope diverge when the knob of the electroscope is touched with a charged object.

15. Is it necessary for a charged object to touch the electroscope for the leaves to diverge? Explain.

16. Give an example and explanation of how a positively charged object can be used to charge an object negatively.

17. You come across an electroscope with an unknown charge, how can you determine the charge on it?

18. If a glass rod is rubbed with a plastic bag and acquires a certain charge, why does the plastic bag have exactly the same amount of opposite charge?

19. A metal ball A on an insulated stand and a similar metal ball B are 1 m apart. Ball A has a negative charge and ball B has an equal positive charge.
   a) Explain what happens when the two balls are connected by a silk thread.
   b) Explain what happens if the balls are connected by a copper wire.

20. a) What is a ground? b) What does it mean, to ground an object? c) When the electroscope is grounded during the process of charging by induction ... what does grounding do? d) Why are cabinets and outer metal parts of household appliances grounded? e) Why does the earth remain electrically neutral?
21. Find the force exerted by a negative charge of 5.0 \( \text{C} \) and a charge of 1.5 \( \text{C} \) when they are 0.050 m apart. What type of force is it? \(-2.7 \times 10^{-13} \text{ N}\)

22. An attractive force of 6.0 \( \text{N} \) is measured between one charge of 2.0 \( \mu \text{C} \) and the other charge is -3.0 \( \mu \text{C} \). What is the distance between the two charges? \([0.095 \text{ m}]\)

23. A negative charge of 1.7 \( \times 10^{-6} \text{ C} \) exerts a repulsive force of 5.0 \( \text{N} \) on a second charge 0.020 m away. What is the sign and magnitude of the second charge? \([-1.3 \times 10^{-7} \text{ C}]\)

24. Three charges A, B, and C, are placed on the \( x \)-axis as shown in the diagram. The charge on C is +2 \( \mu \text{C} \), the charge on B is -4 \( \mu \text{C} \), and the charge on A is -8 \( \mu \text{C} \). The distance between A and B, \( r_1 \), is 15 cm. The distance between A and C, \( r_2 \), is 18 cm. Determine the net force on A. \([8 \text{ N}]\)

25. A metal sphere has a mass of 1.22 kg and carries a charge of \(-3.34 \text{ nC}\). Determine the size of the charge required to levitate the sphere 1.00 cm above the charge. \([3.89 \times 10^{-5} \text{ C}]\)

26. Two 1.00 kg objects (assume point masses) each carry 1.00 \( \text{C} \) of negative charge. What is the ratio of Coulomb’s (electrostatic) force to the gravitational force of the objects, at any distance apart? \([1.35 \times 10^{20}]\)

27. Each side of a vertical right-angled isosceles triangle measures 1.87 cm. Three charged objects are placed at the vertices (corners) of the triangle. Each of the two objects at the vertices of the base has a charge of +5.00 \( \mu \text{C} \). The object at the top vertex (right angle) of the triangle has a charge of +4.74 \( \mu \text{C} \). What is the net force on the object at the top vertex? \([8.50 \times 10^{-1} \text{ N(Up)}]\)

28. The charges +2.0 \( \mu \text{C} \), +3.0 \( \mu \text{C} \), and +4.0 \( \mu \text{C} \) are placed at points A, B, and C of an equilateral triangle with each side of 0.20 m. Determine the force on the charge +4.0 \( \mu \text{C} \) placed at the point C \([3.9 \text{ N}]\)

29. Charges A and B are placed on the \( x \)-axis. Another charges C is placed below A. The magnitude of charge A is -7.0 \( \mu \text{C} \) and that of charge B is -8.0 \( \mu \text{C} \). The magnitude of the charge C is +6.0 \( \mu \text{C} \). The distance between A and B is 14.0 cm and the distance between B and C is 20.0 cm. What is the net force on charge A? \([26 \text{ N}]\)