Conceptual Physics NAME:

Homework 5a Electrostatics Homeworks are due usually a day after the corresponding textbook part/lecture is completed. Due dates will be announced in class. Multiple-choice problems will all be marked. **USE** the answer table for these problems. The rest of the homeworks will be marked for apparent completeness and some full-answer problems will/may be marked in detail. Make the full-answer solutions sufficiently detailed that the grader can follow your reasoning. Solutions will be posted eventually after the due dates. The solutions are intended to be (but not necessarily are) super-perfect and often go beyond full answers. For an argument or discussion problem, there really is no single right answer. The instructor's answer reflects his long experience in physics, but there could be objections to his arguments, assumptions, nuances, style, facts, etc.

NAME:

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	26.	O	O	O	O	O
2.	O	O	O	O	O	27.	O	O	O	O	O
3.	O	O	O	O	O	28.	O	O	O	O	O
4.	O	O	O	O	O	29.	O	O	O	O	O
5.	O	O	O	O	O	30.	O	O	O	O	O
6.	O	O	O	O	O	31.	O	O	O	O	O
7.	O	O	O	O	O	32.	O	O	O	O	O
8.	O	O	O	O	O	33.	O	O	O	O	O
9.	O	O	O	O	O	34.	O	O	O	O	O
10.	O	O	O	O	O	35.	O	O	O	O	O
11.	O	O	O	O	O	36.	O	O	O	O	O
12.	O	O	O	O	O	37.	O	O	O	O	O
13.	O	O	O	O	O	38.	O	O	O	O	O
14.	O	O	O	O	O	39.	O	O	O	O	O
15.	O	O	O	O	O	40.	O	O	O	O	O
16.	O	O	O	O	O	41.	O	O	O	O	O
17.	O	O	O	O	O	42.	O	O	O	O	O
18.	O	O	O	O	O	43.	O	O	O	O	O
19.	O	O	O	O	O	44.	O	O	O	O	O
20.	O	O	O	O	O	45.	O	O	O	O	O
21.	O	O	O	O	O	46.	O	O	O	O	O
22.	O	O	O	O	O	47.	O	O	O	O	O
23.	O	O	O	O	O	48.	O	O	O	O	O
24.	O	O	O	O	O	49.	O	O	O	O	O
25.	O	O	O	O	O	50.	O	O	O	O	O

1. "Let's play *Jeopardy*! For $100, the answer is: It is the realm of physics concerned with electrical and magnetic phenonema: i.e., electricity and magnetism. Electricity and magnetism are, in fact, two manifestations of the same underlying realm: i.e., the realm in question."

   What is _____, Alex?

   a) mechanics b) waves c) thermodynamics d) magnetoelectricity
   e) electromagnetism

2. Who named positive and negative electric charge?

   a) George Washington (1732–1799). b) John Adams (1735–1826).
   c) Benedict Arnold (1741–1801). d) Aaron Burr (1756–1836).
   e) Benjamin Franklin (1706–1790).

3. Electric charge is:

   a) a fundamental property of matter: it comes in invariant quantized amounts of size $\pm e$.
   b) a derived property of matter: it comes in somewhat variable quantized amounts of size $\pm e$ more or less.
   c) a fundamental property of matter which comes in a continuum of quantities: there is no smallest bit of charge.
   d) a derived property of matter which comes in a continuum of quantities: there is no smallest bit of charge.
   e) amber.

4. Electric charge is a cause (but not the only one in direct sense) of the electric field. The electric field is the direct cause of the electric force in the modern conception of electromagnetism. Thus, in a indirect sense, charge is a cause of:

   a) the Hooke's law force b) the gravitational force. c) the electric force.
   d) short circuits e) electric bills.

5. There are two kinds of electric charge:

   a) black and white. b) north and south. c) positive and negative. d) left and right.
   e) up and down.

6. Like charges _____ and unlike charges _____.

   a) repel; attract b) attract; repel c) repel; repel d) attract; repel
   e) compel; detract

7. Net charge is _____. Positive are and negative charge are _____.

   a) not conserved; conserved b) not conserved; not conserved c) conserved; conserved
   d) conserved; not conserved e) sometimes conserved; not conserved

8. The absolute value of the smallest nonzero physical amount of electric charge (not considering quarks) is:

   a) e or $1.602\ldots \times 10^{-19}\,\mathrm{C}$. b) $1\,\mathrm{C}$. c) indefinitely small. d) indefinitely large.
   e) indeterminate.

9. "Let's play *Jeopardy*! For $100, the answer is: It is usually approximately electrically neutral."

   What is _____, Alex?

   a) an electron b) a proton c) highly charged matter
   d) highly negatively charged matter e) ordinary, terrestrial matter above the atomic scale

10. Why don't positive and negative charge largely neutralize each other at the microscopic level just like they mostly do at the macroscopic level? The short answer is it is forbidden in most circumstances by _____.

    a) classical physics b) James Clerk Maxwell c) Michael Faraday d) Ben Franklin
    e) quantum mechanics

11. Electrons in an atom are:

a) permanently bound to the atom. b) not permanently bound to the atom.
c) confined to the nucleus. d) more massive than the nuclues. e) green.

12. Given the mass of a proton is $1.67 \times 10^{-24}\,\mathrm{g}$ and the elementary charge is $1.602 \times 10^{-19}\,\mathrm{C}$, what approximately is the total charge of 1 g of protons?

    a) $1.67 \times 10^{-24}\,\mathrm{C}$. b) $1.602 \times 10^{-19}\,\mathrm{C}$. c) $10^{5}\,\mathrm{C}$. d) $2.5 \times 10^{-43}\,\mathrm{C}$. e) zero.

13. "Let's play *Jeopardy*! For $100, the answer is:

$$F = \frac{kq_1q_2}{r^2}\ ,$$

    where $k = 8.987\ldots \times 10^9$ in MKS units is Coulomb's constant, q_1 is the charge on object 1, q_2 is the charge on object 2, r is the distance between the objects, and F is the magnitude of force between the objects. This formula holds for objects which are must smaller in size scale than r or are spherically symmetric and not overlapping."

    What is _____, Alex?

    a) Volta's law b) Ohm's law c) Ampere's law d) Franklin's law e) Coulomb's law

14. Coulomb's law is a:

    a) societal law. b) law of thermodynamics. c) law of motion. d) conservation law.
    e) force law.

15. For two **POINT** masses to exert a Coulomb force on each other:

    a) both must be uncharged. b) both must be charged. c) one must charged and the other uncharged. d) their charges must both be greater than 1 C. e) their charges must both be less than 1 C.

16. Coulomb's law is an:

    a) cube law. b) square law. c) inverse-sine law. d) inverse-cube law.
    e) inverse-square law.

17. If you **DOUBLE** the distance between charged particles, the force between them:

    a) increases by a factor of 4. b) decreases by a factor of 4. c) decreases by a factor of 2.
    d) increases by a factor of 2. e) decreases by a factor of 9.

18. The electrostatic force and gravity are both _____ force laws.

    a) inverse-linear b) inverse-square c) inverse-cube d) linear e) quadratic

19. Coulomb's law and the point-mass gravitational formula in scalar form are, respectively:

$$F_{\mathrm{C}} = \frac{kq_1q_2}{r^2} \qquad \text{and} \qquad F_{\mathrm{G}} = \frac{Gm_1m_2}{r^2}\ ,$$

    where $k = 8.98755179 \times 10^9\,\mathrm{N\,m^2/C^2}$, $G = 6.67428(67) \times 10^{-11}$ in MKS units, q stands for charge, m for mass, 1 and 2 for particles 1 and 2, and r is the distance between the particles. The mass of electrons is $9.1093826 \times 10^{-31}\,\mathrm{kg}$ and their electric charge is $1.60217653 \times 10^{-19}\,\mathrm{C}$. Approximately, what is the ratio of the magnitude of gravitational force to the magnitude of the electrical force between two electrons (i.e., $F_{\mathrm{G}}/F_{\mathrm{C}}$) for any distance r?

    a) 1. b) 10. c) 3×10^{-43}. d) 3×10^{43}. e) 10^{-19}.

20. The electric field is a vector field. At each point in space it has a magnitude and a direction. The direction is in real space. The extent of the electric field vector is in its own abstract space. The electric field is the direct cause of:

    a) gravitational force. b) magnetic force. c) electric force. d) charge. e) pressure.

21. The general formula for the electric force on a point charge q caused by an electric field $\vec{E}$ is:

    a) $\vec{F} = q/\vec{E}$. b) $\vec{F} = \vec{E}/q$. c) $\vec{F} = q\vec{E}$. d) $\vec{F} = q^2\vec{E}$. e) $\vec{F} = \vec{E}/q^2$.

22. "Let's play *Jeopardy*! For $100, the answer is: These curves are tangent to the electric field vector at every point along then. They point in the direction of the electric field. On positive charge, they only start; on negative charge they only end. They can extend to infinity or, when caused by the Maxwell-Faraday law of induction, form closed loops. They can never cross since a vector cannot point two ways at once, except they can cross when the electric field goes to zero since a zero vector has an indeterminate direction."

    What are _____, Alex?

    a) zigzags. b) equipotential lines c) magnetic field lines d) electric field lines
    e) dipole field lines

23. In electrostatic cases, the electric field lines at a conductor surface are always _____ to the surface.

    a) outward b) randomly oriented c) parallel d) normal e) inward

24. There are four main charge conduction categories for material:

    a) insulator, conductor, demiconductor, orchestra conductor.
    b) insulator, conductor, semiconductor, infraconductor.
    c) insulator, conductor, semiconductor, Superman-conductor.
    d) insulator, conductor, semiconductor, superconductor.
    e) insulator, conductor, semiconductor, demisemiconductor.

25. "Let's play *Jeopardy*! For $100, the answer is: These materials allow an electric current to flow through them easily."

    What are _____, Alex?

    a) insulators b) conductors c) vacuum states d) solids e) crystals

26. "Let's play *Jeopardy*! For $100, the answer is: These materials do **NOT** allow an electric current to flow through them easily."

    What are _____, Alex?

    a) insulators b) conductors c) vacuum states d) solids e) crystals

27. "Let's play *Jeopardy*! For $100, the answer is: In electrostatic cases, these materials have no macroscopic electric field in their interiors, have electric field normal to their surfaces, have no macroscopic net charge in their interiors, and have any net charge on their surfaces. In the macroscopic picture we are using, the surface is an infinitely thin, inpenetrable barrier."

    What are _____, Alex?

    a) insulators b) superconductors c) gases d) liquids e) conductors

28. A good conductor in an electrostatic case will have no electric field in any cavity caused by charges in the conductor or by an external applied field. Thus, the conductor shields the cavity from external fields. Although perfect shielding is only guaranteed in exactly electrostatic cases with the cavity having no holes to the outside, in practice, the shielding is often pretty good for even pretty rapidly varying external electric fields and for cavities with quite a few holes. Thus, practical structures for very general shielding are easy to make and, in fact, are ubiquitous in technology. These structures are called:

    a) Faraday cages. b) Faraday traps. c) Faraday shields. d) Ampere traps.
    e) Coulomb traps.

29. Two uncharged conducting balls A and B are mounted on insulating stands. The balls are touching. A positively charged rod is brought from infinity to near B, but not near A. The balls are then separated and the rod is put back at infinity. The charges on A and B are, respectively:

    a) positive and positive. b) negative and negative. c) negative and positive.
    d) positive and negative. e) zero and zero.

30. Charge separation in a object is called:

    a) rasterization. b) pasteurization. c) polarization. d) north polarization.
    e) miniaturization.

31. Can two finite bodies each electrically neutral overall ever attract or repel each other?

    a) No.
    b) Always.
    c) Always and no.
    d) **YES**. For example, consider two small, non-conducting balls attached by a non-conducting bar: give one ball a positive charge (uniformly spread) and the other ball a negative charge (uniformly spread) of the same magnitude. The structure is an electric dipole that is overall neutral. Now consider a second identical dipole. Align the two with unlike ends closest and then with like ends closest. The distance between the balls is a fixed distance a in both cases. The force between the two unlike ends is attractive and between the like ends is repulsive. What of the other forces between the balls? We can make the bars as long as we like. The other forces between the balls get smaller and smaller as we make the bars longer and longer. Eventually the other forces become negligible and the closest ball forces dominate.
    e) They can **REPEL**, but never **ATTRACT**. That is the valid conclusion of answer (d).

32. Electric potential (AKA voltage) is the electric potential energy:

    a) period. b) divided by the electric field magnitude. c) per unit point charge.
    d) always negative. e) always positive.

33. The standard symbol for electrical potential is _____ and the MKS unit is _____.

    a) J; joule (J) b) V; joule (J) c) V; joule (J) d) V; volt (V) e) V; volt (V)