1. The electric field at point P is shown in the picture below. If a neutral atom is placed at point P, in what direction would it be polarized? Sketch a picture of the polarized atom and draw the dipole moment $\vec{p}$ vector of the neutral atom.

![Figure 1](image.png)

2. Two charged particles are near a hydrogen atom. Sketch the following vectors: (1) the force of $+q$ on the H atom; (2) the force of $-q$ on the H atom; and (3) the net force on the H atom.

![Figure 2](image.png)

3. If two neutral atoms are close together, will they attract, repel, or not interact at all? Explain your answer thoroughly and draw pictures if necessary.
A hydrogen atom is near a charged particle as shown below. The distance between them is \( d = 2.0 \times 10^{-7} \text{ m} \). The polarizability of hydrogen is \( 7.42 \times 10^{-41} \text{ C}^2 \text{ m/N} \).

4. What is the electric field of the charged particle at the location of the H atom? Express this as a vector and draw it on the picture.

5. What is the induced dipole moment of the hydrogen atom? Express this as a vector and draw it on the picture.

6. What is force on the hydrogen atom? Express this as a vector and draw it on the picture.
7. Suppose the force on the hydrogen atom in the previous question has a magnitude of $F$. If you decrease the distance between between the atom and particle by 1/2, what is the magnitude of the force on the atom?

(a) $32F$
(b) $8F$
(c) $4F$
(d) $2F$
(e) $F/2$
(f) $F/4$
(g) $F/8$
(h) $F/32$

8. What type of material has mobile electrons that can move throughout the material?

(a) conductor
(b) insulator
(c) both a conductor and an insulator
(d) neither a conductor nor an insulator

9. If this type of material is placed into an electric field, individual atoms or molecules within the material become polarized, depending on the direction of the electric field. Thus, the net electric field within the material is not zero.

(a) conductor
(b) insulator
(c) both a conductor and an insulator
(d) neither a conductor nor an insulator

10. If this type of material is placed into an electric field, the entire object becomes polarized due to the net displacement of a “sea of electrons”? The electrons eventually reach equilibrium where the force due to the applied electric field balances the force due to nearby electrons. The net electric field inside the material is thus zero.

(a) conductor
(b) insulator
(c) both a conductor and an insulator
(d) neither a conductor nor an insulator

11. If this type of material, excess electrons will move until they are as far apart as possible. This means that excess charge will lie along the surface of the material.

(a) conductor
(b) insulator
(c) both a conductor and an insulator
(d) neither a conductor nor an insulator

12. If you place a piece of tape on top of another piece of tape such that only half of it is sticking to it and then you rip it off, half the tape will have excess charge while the other half remains neutral. In other words, excess charge does not distribute itself over the entire piece of tape. This means that the tape is

(a) a conductor
(b) a insulator
(c) both a conductor and an insulator
(d) neither a conductor nor an insulator

13. If you stick two pieces of tape together (bottom to top), make sure they are neutrally charged, and then rip them apart, one piece of tape will have a charge $+Q$ and another piece will have a charge $-Q$. It’s impossible for one piece of tape to have a greater number of excess electrons (or protons) than the other one, if it’s a closed system. What principle tells us this is true?

(a) the momentum principle
(b) the energy principle
(c) superposition
(d) conservation of charge
(e) Coulomb’s law
1. The electric field will cause the neutral atom to polarize with the negative side away from the electric field and the positive side toward the electric field. The dipole moment $\vec{p}$ points from the negatively charged side to the positively charged side.

2. A charged particle always attracts a neutral atom. The force of $+q$ on the neutral atom is down and to the left. The force of $-q$ on the neutral atom is down and to the right. The net force on the neutral atom is therefore in the $-y$ direction.

3. The electron clouds will repel each other and will shift away from each other. Thus, the two atoms will be polarized with their positive cores near each other. As a result, the atoms will repel. That’s how atoms in a gas “collide.”

4. $\vec{E} = <3.6 \times 10^4, 0, 0> \text{ N/C}$

5. $\vec{p} = <2.67 \times 10^{-36}, 0, 0> \text{ C m}$

6. $\vec{F} = <-9.62 \times 10^{-25}, 0, 0> \text{ N}$

7. (a)

8. (a)

9. (b)

10. (a)

11. (a)

12. (b)

13. (d)