7. REVIEW QUESTIONS

1. State the law of conservation of charge. Why is it so important that charge be conserved?

2. What proof do we have that charge is conserved?

3. What proof do we have that the electron is the smallest unit of charge in nature?

4. What is electric current? How does it relate to charge?

5. Why is current density a more fundamental quantity than current? Explain.

6. We say that current flows in one direction or the other. How does this reconcile with the fact that current is a scalar quantity? Explain.

7. Convince yourself of the differences between conduction and convection currents.

8. Current in a semiconductor is due to mobility of holes and electrons. Is this a conduction or a convection current? Explain your answer.

9. In a system $\nabla \cdot \mathbf{J} = 5$, what can we say about the type of current density **J**?

10. Which of the following fields represent systems with steady currents for σ = constant?

(a) $\mathbf{J} = \hat{\mathbf{x}}5x + \hat{\mathbf{y}}b$

(b) $\mathbf{E} = -\hat{\boldsymbol{\phi}}3$

(c) $\mathbf{E} = -\hat{\boldsymbol{\theta}}r$

(d) $\mathbf{J} = \hat{\mathbf{x}}3\mathrm{y} + \hat{\mathbf{z}}3x$

11. State Ohm's law for circuits and for fields. How do the two statements relate?

12. Ohm's law applies to conduction as well as convection currents *T/F*. Explain.

13. Write Ohm's law in terms of current density, starting with Ohm's Law in its circuit form.

14. Resistance is independent of current *T/F*. Is this always so?

15. Resistance is a macroscopic measure of collisions of electrons and atoms and, therefore, of mobility of electrons in a conductor *T/F*.

16. Suppose the current in a conductor is known. Show how the resistance of the conductor can be calculated using the general formula for resistance. What must necessarily be the assumptions to be imposed on the conductor

17. State Joule's law for circuits and for fields. How do the two statements relate?

18. Why isn't it possible to increase current density in a conductor beyond a certain level? What would happen if we did?

19. Power is the time rate of change of energy. Convince yourself of this by using, say, **Eq. (7.23)**.

20. What does the continuity equation state? Why is this statement important?

21. What are the differences between Kirchhoff's current law for circuits and for fields?

22. What is a steady current? Is this the same as dc current? Explain.

23. Are there differences between steady and transient currents as far as Kirchhoff's laws are concerned?

24. State the interface conditions for current density based on the known conditions for the electric field intensity.

25. Compare Kirchhoff's voltage law for circuits and for fields. What are the differences between them?

26. Explain why at the interface between two finite conductivity materials, across which there is a current, there must be a surface charge density.

27. Give a simple method of measuring conductivity of a solid material.

28. Discuss a few common, simple sensors based on resistance.

29. Suppose we could build perfect superconducting power distribution systems. How would the fusing of such systems be done?