Why a Comb Stays Charged but a Spoon Doesn't: Conductors, Insulators and Earthing

Rub a plastic comb on dry hair and it lifts paper bits; rub a steel spoon and nothing happens. Rubbing moves electrons, and what happens next depends on the material. Conductors (metals, the human body, the earth) have free electrons, so charge spreads over them and leaks away through the hand and body into the earth. Insulators (plastic, glass, nylon, wood) hold their electrons bound, so charge stays where it was put. Earthing connects a body to the earth, a giant charge reservoir; at home the earth wire and fuse use it for safety, and fuel tankers are earthed to prevent static sparks.

Name: _____ Date: _____ Score: ____ / 24

A. Fill in the blanks

1. Materials that let charge move through them easily are called ____.

2. Materials that do not let charge move through them easily are called ____.

3. Copper has about ____ free electron per atom.

4. Connecting a charged body to the earth so its extra charge flows away is called ____.

5. Silicon, which lies between conductors and insulators, is a ____.

B. True or False

6. The human body is an insulator. True / False

7. In an insulator, the electrons are bound to their atoms. True / False

8. Charge given to a conductor spreads over its whole surface. True / False

9. Metals can never be charged by rubbing. True / False

C. Assertion and reason

10. Assertion (A): Assertion: A metal rod held in the hand cannot be charged by rubbing. Reason: The human body is a conductor.
Reason (R): Both true; the reason explains the assertion.

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

11. Assertion (A): Assertion: Charge given to an insulator spreads over its surface. Reason: Insulators have many free electrons.
Reason (R): Both false: charge on an insulator stays put; its electrons are bound.

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

D. Choose the correct option

12. Which of these is a conductor?

(a) glass
(b) nylon
(c) human body
(d) porcelain

Answer: _____

13. A steel spoon held in the hand does not stay charged after rubbing because:

(a) metals have no electrons
(b) the charge flows through the body to the earth
(c) rubbing cannot move electrons
(d) steel is an insulator

Answer: _____

14. The earth wire of an appliance is joined to:

(a) the live wire
(b) the neutral wire
(c) the metal body
(d) the switch

Answer: _____

15. The resistivity of glass is larger than copper's by roughly a factor of:

(a) 10^{2}
(b) 10^{6}
(c) 10^{18}
(d) 10^{40}

Answer: _____

E. Numerical problems

16. Estimate the earth's capacitance $C = 4\pi\varepsilon_0 R$ with $R = 6.4 \times 10^{6}$ m.

17. Estimate the free-electron density of copper (density 8.96×10^{3} kg/m³, molar mass 63.5 g/mol, one free electron per atom).

F. Short answer questions

18. Why does a plastic comb get charged on combing dry hair but a steel spoon held in the hand does not?

19. How can a metal rod be charged by rubbing?

20. Why is the earth called a giant charge reservoir?

21. Describe how the earth wire protects a person using an electric iron.

22. Why are fuel tankers earthed before refuelling?

23. Why do you sometimes get a shock touching a metal door knob after walking on a carpet?

G. Match the columns

24. Match each item in Column A with the correct item in Column B.

Column A	Column B	Your answer
1. copper, iron, human body, earth	(a) insulators	1 → ____
2. glass, plastic, nylon, wood	(b) conductors	2 → ____

Detailed solutions

1. conductors

2. insulators

3. one

4. earthing (grounding)

5. semiconductor

6. False. It is a conductor, so charge on a hand-held metal rod leaks through it to the earth.

7. True. So charge stays where it was put.

8. True. Free electrons move until the charge is spread out.

9. False. They can, if held by an insulating handle so the charge cannot leak away.

10. (a)

11. (a)

12. (c) human body. The body conducts.

13. (b) the charge flows through the body to the earth. The leak to the earth.

14. (c) the metal body. So a fault current goes to the ground and the fuse blows.

15. (c) 10^{18}. $10^{10} / 1.7 \times 10^{-8} \approx 6 \times 10^{17}$.

16. $4\pi \times 8.85 \times 10^{-12} \times 6.4 \times 10^{6}$. **Answer: $\approx 7 \times 10^{-4}$ F (about 700 μF)**

17. $(8.96 \times 10^{3} / 0.0635) \times 6.02 \times 10^{23}$. **Answer: $\approx 8.5 \times 10^{28}$ per m³**

18. Plastic is an insulator, so the charge stays where it was rubbed; the spoon is a conductor, so its charge flows through the hand and body to the earth.

19. Hold it by a plastic (insulating) handle, so the charge has no path to the earth.

20. It is so large that adding or removing charge hardly changes it, like a bucket of water poured into the ocean.

21. The metal body is joined by the earth wire to a plate buried deep in the ground. If the live wire touches the body, current flows through the low-resistance earth wire instead of the person, and the fuse blows.

22. So static charge cannot build up and cause a spark that could ignite the fuel vapour.

23. Your body is charged by friction while your shoes insulate it from the ground; the charge jumps to the metal knob.

24. 1 → (b), 2 → (a).