Why are Transition Metals Coloured Worksheet (Includes Answers)

Resources:
www.youtube.com/watch?v=8ugSVOkA1xo
www.somethingcalledscience.com/post/why-transition-metals-are-coloured

Name: ___________________________ **Date:** ______________

Part 1: Understanding the Basics

1. What are transition metals, and where are they located on the periodic table?

2. Name three examples of transition metals.

a) ______________________

b) ______________________

c) ______________________

3. What is special about d-orbitals in transition metals that allows their compounds to be coloured?

4. How many d-orbitals does a transition metal have, and how many electrons can they hold in total?

Part 2: Crystal Field Splitting

5. What happens to the five d-orbitals when a transition metal forms a compound?

6. What causes the d-orbitals to split into different energy levels?

7. What is this splitting phenomenon called? (Give both names)

8. What is a ligand?

Part 3: Light and Colour

9. What is white light composed of?

10. When white light shines on a transition metal compound, what happens to certain colours of light?

11. Complete this statement: The colour we see is _______ the colour that was absorbed—it's the colour that was ________________.

12. What two factors determine which colour of light gets absorbed by a transition metal compound?

a) ____

b) ____

Part 4: Real-World Examples

13. Rust is orange-brown in colour.

a) What is rust mainly composed of?

b) Which colours does rust absorb?

c) Which colours are left over for us to see?

14. Blood is red. What transition metal is responsible for this colour, and where is it found in blood?

15. Ruby gemstones are deep red.

a) Which transition metal causes this colour?

b) What is the base material that contains these metal impurities?

16. Why does the Statue of Liberty have a blue-green colour?

Part 5: Why Other Elements Aren't Coloured

17. List three reasons why most other elements don't show vibrant colours like transition metals do:

a) ____

b) ____

c) ____

18. Give an example of an element for each reason above:

a) ____________________

b) ____________________

c) ____________________

19. Is zinc a transition metal? Why is it an exception to the colour rule?

20. What does it mean that transition metals are in the "Goldilocks zone"?

Part 6: The Complementary Colour Wheel

21. If a compound absorbs red light, what colour will it appear?

22. If a compound absorbs green light, what colour will it appear?

23. If a compound appears blue, what colour(s) is it likely absorbing?

Part 7: Critical Thinking

24. Explain in your own words why freshly exposed iron metal (silvery-grey) doesn't have colour, but rust (iron oxide) does.

25. A student says: "Transition metal compounds are coloured because they reflect certain colours." Explain what's wrong with this statement and provide the correct explanation.

26. Can non-transition-metal compounds be coloured? If so, is it for the same reason as transition metals?

Bonus Question

27. If you had two copper compounds—one bonded to water molecules and one bonded to ammonia molecules—would they be the same colour? Explain your reasoning.

Answer Key

Part 1: Understanding the Basics

1. Transition metals are elements found in the middle section, or d-block, of the periodic table.

2. Any three of: iron (Fe), copper (Cu), manganese (Mn), chromium (Cr), nickel (Ni), cobalt (Co), etc.

3. Transition metals have partially filled d-orbitals, meaning some (but not all) of these orbitals contain electrons, allowing electrons to jump between energy levels.

4. Five d-orbitals that can hold up to 10 electrons total (2 electrons per orbital).

Part 2: Crystal Field Splitting

5. The five d-orbitals split into two groups with different energy levels—some become slightly higher in energy and others become slightly lower in energy.

6. The electric field created by the surrounding ligands (atoms or molecules bonded to the metal) causes the splitting.

7. Crystal Field Splitting (or Ligand Field Splitting)

8. A ligand is an atom or molecule that bonds to a transition metal atom in a complex.

Part 3: Light and Colour

9. White light is composed of all colours of the rainbow (red, orange, yellow, green, blue, indigo, violet).

10. Electrons in the lower-energy d-orbitals absorb specific colours of light (those that match the energy gap), and use that energy to jump to higher-energy d-orbitals.

11. The colour we see is **NOT** the colour that was absorbed—it's the colour that was **LEFT OVER**.

12. a) The type of metal b) What ligands surround it (what atoms or molecules it's bonded to)

Part 4: Real-World Examples

13. a) Hydrated iron(III) oxides b) Blue-green light c) Orange, red, and brown wavelengths

14. Iron, found in hemoglobin (the iron atoms in blood cells absorb blue-green light, leaving red light to reach our eyes).

15. a) Chromium b) Aluminum oxide

16. The blue-green copper patina coating forms when copper reacts with air and moisture. The copper compounds absorb red light, leaving blue-green colours visible.

Part 5: Why Other Elements Aren't Coloured

17. a) They don't have d-orbitals with electrons, so there's nowhere for electrons to jump b) Their d-orbitals are completely full, so electrons can't jump to higher d-orbitals—there's no room c) The energy gaps are too small or too large to match visible light colours

18. a) Sodium or calcium b) Zinc c) Sodium

19. Yes, zinc is a transition metal by its position on the periodic table, but it's an exception to the colour rule because its d-orbitals are completely full, so electrons cannot jump to higher d-orbitals.

20. Transition metals have partially filled d-orbitals AND the energy gaps are just right for absorbing visible light—not too large and not too small.

Part 6: The Complementary Colour Wheel

21. Green

22. Red

23. Red-orange light (or yellow-orange)

Part 7: Critical Thinking

24. Pure iron metal doesn't have the right structure to absorb visible light and create colour. When iron forms iron oxide (rust), the iron atoms become surrounded by oxygen atoms. This arrangement causes the d-orbitals to split into different energy levels, allowing the compound to absorb blue-green light and appear orange-brown.

25. The statement is incomplete/misleading. Transition metal compounds don't just reflect certain colours—they **absorb** specific colours of light when electrons jump between split d-orbitals. The colour we see is the **leftover light** that wasn't absorbed, which is then reflected or transmitted to our eyes.

26. Yes, non-transition-metal compounds can be coloured, but for different reasons—such as charge transfer—not because of d-orbital electron transitions.

Bonus Question

27. No, they would likely be different colours. The colour depends on both the type of metal AND what ligands surround it. Different ligands (water vs. ammonia) create different electric fields, which cause different amounts of d-orbital splitting, leading to different energy gaps and therefore different colours being absorbed.