# 1.3 Transition metals

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

**KEY WORDS** transition metal • catalyst • coloured compound

## Objective

Compare transition metals with Group 1 and describe their typical properties. Chemistry only. Original questions for spec statement 4.1.3.

## 1 Key knowledge and worked examples

The **transition elements** (Cr, Mn, Fe, Co, Ni, Cu are your examples) sit between Groups 2 and 3. Compared with Group 1 they have:

- **higher melting points** for the named examples;
- **higher densities**;
- greater **strength** and **hardness**;
- **lower reactivity** with oxygen, water and halogens.

Typical properties:

- **many form ions with more than one charge** – $Fe^{2+}$ and $Fe^{3+}$, $Cu^{2+}$ and $Cu^{+}$ (Group 1 is always +1);
- **coloured compounds** – aqueous iron(II) salts can be pale green, iron(III) salts yellow-brown and copper(II) salts blue; colour depends on the compound and conditions;
- **catalytic activity** – iron in the Haber process, nickel in hydrogenation.

**Worked example (3 marks).** A student says "copper and sodium are both metals so they behave the same." Correct them with two properties.

No – copper is a transition element and sodium a Group 1 alkali metal; copper is harder, denser and has a much higher melting point; copper is much less reactive – it does not react with cold water, while sodium fizzes violently.

## 2 Practice

**2.1** Give two differences between transition metals and Group 1 metals in physical properties. [2]

**2.2** Give the formulas of the two common iron ions, and typical colours of their aqueous salts. [3]

**2.3** Name the transition metal used as a catalyst in the Haber process. [1]

## 3 Exam-style questions

**3.1** Compare the reactions of potassium and copper with water and with dilute hydrochloric acid, explaining the difference in terms of reactivity. [4]

**3.2** Explain why iron(II) sulfate and iron(III) sulfate are different compounds, even though both contain only iron, sulfur and oxygen. [3]

**3.3** Chromium is a transition metal. Predict three characteristic physical properties and give one example of a transition metal used as a catalyst. [4]

**3.4** Fictional metalsP/Q have densities0.8/8.0g/cm$^3$ and melting points80/1400°C. P reacts rapidly with cold water; Q does not. Which is more consistent with a transition metal rather than Group 1? Use three independent observations. [3]

**3.5** Sulfate ions are$SO_4{}^{2-}$. Give the formulas of iron(II) sulfate and iron(III) sulfate and explain how the ion charges determine the different proportions. [3]

**3.6** A reaction is repeated with and without a transition-metal catalyst under otherwise identical conditions. Suggest the expected rate difference and one suitable measurement. Explain why a coloured compound is not automatically a catalyst and why a catalyst is not a source of product atoms. [4]

## Solutions

**2.1** Any two: transition metals have higher melting points; higher densities; harder; stronger.

**2.2** $Fe^{2+}$ – pale green compounds; $Fe^{3+}$ – yellow/brown compounds.

**2.3** Iron.

**3.1** Potassium reacts vigorously with cold water – fizzing, melting into a ball, producing hydrogen and potassium hydroxide; copper has no reaction with water. Potassium reacts explosively/fast with dilute acid; copper does not react with dilute hydrochloric acid – it is below hydrogen in the reactivity series. Transition metals are much less reactive than Group 1 metals.

**3.2** The iron is present as different ions – $Fe^{2+}$ in iron(II) sulfate and $Fe^{3+}$ in iron(III) sulfate; transition elements form ions with different charges; so the two compounds have different formulae ($FeSO_4$, $Fe_2(SO_4)_3$) and different colours/properties despite containing the same elements.

**3.3** Any three distinct physical predictions: high melting point, high density, hard, strong. Catalyst example: iron in the Haber process or nickel in hydrogenation. These are typical comparisons with Group 1, not universal properties of every transition compound.

**3.4** Q: higher density, higher melting point, lower reactivity with cold water fit the typical comparison. These observations support a classification; they do not identify the exact element or prove all its compounds are coloured.

**3.5** $FeSO_4$; $Fe_2(SO_4)_3$. $Fe^{2+}$ and ${SO_4}^{2-}$ balance 1:1; two $Fe^{3+}$ (+6) balance three ${SO_4}^{2-}$ (−6). The same element names do not guarantee the same compound.

**3.6** Catalyst increases rate; measure product volume per time or time to a specified endpoint with other conditions controlled. Colour alone is not evidence of faster reaction/catalytic behaviour. A catalyst is regenerated/not consumed overall; product atoms come from reactants.