

Exercise walk-through

General physical and chemical properties of the first row of transition ■ 28.1

eXercise

You must be able to

- define a transition element and explain why Sc and Zn are excluded
- state the four key properties (variable oxidation state, catalysis, complexes, colour) and why

Method — What a transition element is

A **transition element** is a d-block element that forms one or more stable ions with **incomplete d orbitals**. (Sc and Zn are excluded: their stable ions have empty or full d orbitals.)

property	reason
variable oxidation state	the 3d and 4s sub-shells are close in energy
act as a catalyst	more than one oxidation state; vacant d orbitals form dative bonds
form complex ions coloured compounds	vacant d orbitals accept lone pairs electrons move between split d orbitals

Method — What a transition element is



Beakers of transition-metal solutions in many different strong colours

Method — What a transition element is



the complex absorbs light of energy ΔE , so we see the **complementary colour**

d-orbital splitting explains colour and variable oxidation states

Practice 2.1 ■ 2 marks

Define a **transition element**.

Solution 2.1

Method: What a transition element is

Worked steps

a d-block element **B1** that forms one or more stable ions with incomplete (partly filled) d orbitals **B1**.

Practice 2.2 ■ 2 marks

State the four characteristic properties of transition elements.

Solution 2.2

Method: What a transition element is

Worked steps

variable oxidation state; catalytic behaviour; form complex ions; form coloured compounds **B1** **B1** *for two, for all four.*

Exam-style 3.1 ■ 1 mark

Why is zinc **not** classed as a transition element?

- A** it is not in the d-block
- B** its stable ion (Zn^{2+}) has a full d sub-shell ($3d^{10}$)
- C** it is colourless
- D** it has no electrons

Solution 3.1

Method: What a transition element is

- A it is not in the d-block
- B its stable ion (Zn^{2+}) has a full d sub-shell ($3d^{10}$)** 
- C it is colourless
- D it has no electrons

Worked steps

B. Zn^{2+} is $3d^{10}$ (a full d sub-shell), so it is not a transition element.

Exam-style 3.2 ■ 1 mark

Transition elements show variable oxidation states because:

- A** their atoms are large
- B** the 3d and 4s sub-shells are close in energy
- C** they are coloured
- D** they are catalysts

Solution 3.2

Method: What a transition element is

- A their atoms are large
- B the 3d and 4s sub-shells are close in energy 
- C they are coloured
- D they are catalysts

Worked steps

B. The close energies of 3d and 4s allow different numbers of electrons to be removed.

Exam-style 3.3 ■ 2 marks

Explain why transition metals can act as catalysts.

Solution 3.3

Worked steps

they have more than one stable oxidation state **M1**; and vacant d orbitals that can form dative bonds with reactants, providing a surface/intermediate **A1**.

Exam-style 3.4 ■ 2 marks

Explain why scandium is not classed as a transition element, with reference to its ion.

Solution 3.4

Method: What a transition element is

Worked steps

scandium's only stable ion is Sc^{3+} **M1**, which has an empty d sub-shell ($3d^0$), so it has no incomplete d orbitals **A1**.