

- 1 Which of the following gives the electronic configurations for a chromium atom and a chromium(II) ion?

	Cr	$^{2+}$
<input type="checkbox"/> A	$[\text{Ar}]3d^44s^2$	$[\text{Ar}]3d^4$
<input type="checkbox"/> B	$[\text{Ar}]3d^54s^1$	$[\text{Ar}]3d^4$
<input type="checkbox"/> C	$[\text{Ar}]3d^44s^2$	$[\text{Ar}]3d^24s^2$
<input type="checkbox"/> D	$[\text{Ar}]3d^54s^1$	$[\text{Ar}]3d^34s^1$

(Total for Question = 1 mark)

- 2 In which of the following ions does the metal have an oxidation number of +3?

- A MnO_4^{2-}
- B VO^{2+}
- C $[\text{Fe}(\text{CN})_6]^{4-}$
- D $[\text{CrCl}_2(\text{H}_2\text{O})_4]^+$

(Total for Question = 1 mark)

- 3 What is the electronic configuration of the stable scandium ion?

- A $[\text{Ar}] 3d^0 4s^2$
- B $[\text{Ar}] 3d^1 4s^1$
- C $[\text{Ar}] 3d^0 4s^1$
- D $[\text{Ar}] 3d^0 4s^0$

(Total for Question = 1 mark)

4 The shapes of the complexes $[\text{CrCl}_4]^-$ and $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ are

	$[\text{CrCl}_4]^-$	$[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
<input type="checkbox"/> A	square planar	square planar
<input type="checkbox"/> B	tetrahedral	tetrahedral
<input type="checkbox"/> C	square planar	tetrahedral
<input type="checkbox"/> D	tetrahedral	square planar

(Total for Question = 1 mark)

5 In which of the following ions does the metal have an oxidation number of +2?

- A MnO_4^{2-}
- B VO^{2+}
- C $[\text{Fe}(\text{CN})_6]^{4-}$
- D $[\text{CrCl}_2(\text{H}_2\text{O})_4]^+$

(Total for Question = 1 mark)

6 The electronic configuration of iron is $[\text{Ar}]3d^64s^2$. What is the electronic configuration of the iron(II) ion, Fe^{2+} ?

- | | | 3d | | | | | 4s |
|----------------------------|------|----|----|----|---|--|----|
| <input type="checkbox"/> A | [Ar] | ↑ | ↑ | | | | ↑ |
| <input type="checkbox"/> B | [Ar] | ↑↓ | ↑ | ↑ | | | |
| <input type="checkbox"/> C | [Ar] | ↑↓ | ↑↓ | ↑ | ↑ | | |
| <input type="checkbox"/> D | [Ar] | ↑↓ | ↑↓ | ↑↓ | | | |

(Total for Question = 1 mark)

7 Chromium has the electronic configuration $[\text{Ar}]3d^54s^1$. Which of the following compounds is **unlikely** to exist?

- A K_3CrO_4
- B CrO_2Cl_2
- C KCrO_2Cl
- D KCrO_4

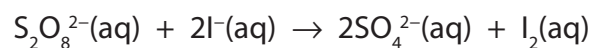
(Total for Question = 1 mark)

8 The shapes of the complexes $[\text{CrCl}_4]^-$ and $[\text{CuCl}_2]^-$ are

	$[\text{CrCl}_4]^-$	$[\text{CuCl}_2]^-$
<input type="checkbox"/> A	tetrahedral	linear
<input type="checkbox"/> B	square planar	linear
<input type="checkbox"/> C	tetrahedral	V-shaped
<input type="checkbox"/> D	square planar	V-shaped

(Total for Question = 1 mark)

9 Consider the following reaction.

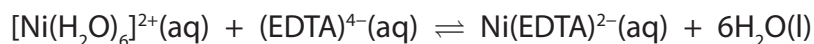


Which of the following ions could catalyse this reaction?

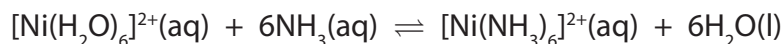
- A Zn^{2+}
- B Al^{3+}
- C Fe^{2+}
- D Na^+

(Total for Question = 1 mark)

10 EDTA ions form a complex with aqueous nickel(II) ions as shown by the equation



Aqueous nickel(II) ions also form a complex ion with ammonia as shown by the equation



Aqueous nickel(II) ions form a more stable complex with EDTA ions than with ammonia because

- A six ammonia ligands cause steric hindrance around the central nickel(II) ion.
- B EDTA ions carry a negative charge whereas ammonia molecules do not.
- C there is a large increase in entropy when aqueous nickel(II) ions react with EDTA ions, but not when aqueous nickel(II) ions react with ammonia.
- D ammonia molecules tend to evaporate from the solution of the complex whereas EDTA ions do not.

(Total for Question = 1 mark)

11 Which of the following shows the correct oxidation states of **chromium** in the ions given?

	$[\text{Cr}(\text{OH})_6]^{3-}$	CrO_4^{2-}	$[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$
<input type="checkbox"/> A	-3	-2	+2
<input type="checkbox"/> B	-3	+10	+2
<input type="checkbox"/> C	+3	+8	+6
<input type="checkbox"/> D	+3	+6	+2

(Total for Question = 1 mark)

12 Transition metals are often used as heterogeneous catalysts. Which of the following processes does **not** occur during such a catalysed reaction?

- A Adsorption of reactant molecules on the surface of the metal.
- B Bond breaking in the reactant molecules.
- C Desorption of product molecules from the surface of the metal.
- D An overall change in the oxidation number of the metal.

(Total for Question = 1 mark)

13 The electronic structure of the chromium(III) ion, Cr^{3+} , is

- | | | 3d | | | | | 4s |
|----------------------------|------|----|---|--|--|--|----|
| <input type="checkbox"/> A | [Ar] | ↑ | | | | | ↑↓ |
| <input type="checkbox"/> B | [Ar] | ↑ | ↑ | | | | ↑ |
| <input type="checkbox"/> C | [Ar] | ↑ | ↑ | | | | |
| <input type="checkbox"/> D | [Ar] | ↑↓ | ↑ | | | | |

(Total for Question = 1 mark)

14 Titanium has the electronic structure $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$. Which of the following compounds is **unlikely** to exist?

- A K_3TiF_6
- B K_2TiF_6
- C $\text{K}_2\text{Ti}_2\text{O}_5$
- D K_2TiO_4

(Total for Question = 1 mark)

15 The ligands that form complex ions are either neutral, like NH_3 , or negatively charged, like CN^- . Nickel(II) ions, Ni^{2+} , form complexes with both these ligands. The bonding between Ni^{2+} and the ligands in these complexes is

	NH_3	CN^-
<input type="checkbox"/> A	dative covalent	dative covalent
<input type="checkbox"/> B	ionic	dative covalent
<input type="checkbox"/> C	dative covalent	ionic
<input type="checkbox"/> D	ionic	ionic

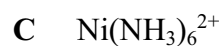
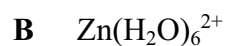
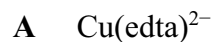
(Total for Question = 1 mark)

16 When excess aqueous ammonia is added to a solution containing $\text{Zn}^{2+}(\text{aq})$ ions, a colourless solution is formed. This solution is colourless because

- A** zinc does not form complex ions.
- B** the d orbitals of Zn^{2+} in the complex formed are not split into different energy levels.
- C** the energy difference between the d orbitals of Zn^{2+} in the complex formed does not correspond to the visible region of the spectrum.
- D** the d orbitals of Zn^{2+} in the complex formed are full.

(Total for Question = 1 mark)

17 Four complex ions have the following formulae:



(a) Which complex ion is most likely to be tetrahedral in shape?

(1)

A

B

C

D

(b) Which complex ion is most likely **not** to be coloured?

(1)

A

B

C

D

(c) Each of these complex ions may be formed by ligand exchange from an aqua complex. For which complex ion is the entropy change of this reaction most positive?

(1)

A

B

C

D

(Total for Question 3 marks)

18 Which of the following successive ionization energies (values in kJ mol^{-1}) could have come from a transition element?

- A 496 4563 6913 9544 13352 16611 20115 25941
- B 590 1145 4912 6474 8144 10496 12320 14207
- C 717 1509 3249 4940 6985 9200 11508 18956
- D 2081 3952 6122 9370 12177 15239 19999 23069

(Total for Question = 1 mark)

19 Which of the following gives the electronic configuration for chromium and for the Cr^{3+} ion?

		Cr	Cr^{3+}
<input type="checkbox"/>	A	$[\text{Ar}]3d^44s^2$	$[\text{Ar}]3d^34s^0$
<input type="checkbox"/>	B	$[\text{Ar}]3d^54s^1$	$[\text{Ar}]3d^24s^1$
<input type="checkbox"/>	C	$[\text{Ar}]3d^54s^1$	$[\text{Ar}]3d^34s^0$
<input type="checkbox"/>	D	$[\text{Ar}]3d^44s^2$	$[\text{Ar}]3d^14s^2$

(Total for Question = 1 mark)

20 Which of the following gives the colours of solutions containing $\text{Cr}_2\text{O}_7^{2-}$, CrO_4^{2-} , hydrated Cr^{3+} and hydrated Cr^{2+} , in this order?

- A Yellow, orange, green, blue
- B Orange, yellow, green, blue
- C Orange, yellow, blue, green
- D Orange, green, yellow, blue

(Total for Question = 1 mark)

21 The compound $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ is

- A tetrahedral with no isomers.
- B square planar with no isomers.
- C tetrahedral with two isomers.
- D square planar with two isomers.

(Total for Question = 1 mark)

22 The hexaaquacopper(II) ion, $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$, is blue because the water ligands

- A split the p -orbital energies and p - p electron transitions emit blue light.
- B split the d -orbital energies and d - d electron transitions absorb all but blue light.
- C split the p -orbital energies and p - p electron transitions absorb all but blue light.
- D split the d -orbital energies and d - d electron transitions emit blue light.

(Total for Question = 1 mark)

23 Vanadium is classified as a transition metal. This is because vanadium

- A is a d-block element.
- B has incompletely filled d orbitals.
- C forms stable ions with incompletely filled d orbitals.
- D forms stable ions in which it has different oxidation states.

(Total for Question = 1 mark)

24 Copper(II) sulfate solution is blue. This is because

- A excited electrons emit light in the blue region of the spectrum as they drop back to the ground state.
- B excited electrons emit light in the red region of the spectrum as they drop back to the ground state.
- C electrons absorb light in the red region of the spectrum and the residual frequencies are observed.
- D electrons absorb light in the blue region of the spectrum and the residual frequencies are observed.

(Total for Question = 1 mark)

25 One method of manufacturing hydrazine (N_2H_4) involves the action of sodium chlorate(I) on excess ammonia at 443 K and 50 atm. The yield is normally around 80% but, if just 1 part per million of copper(II) ions is present, the yield drops to 30%.

The most likely explanation for this is the ability of copper(II) ions to

- A form complex ions with ammonia.
- B catalyse reactions producing other nitrogen compounds.
- C reduce the hydrazine as it is formed.
- D reduce the sodium chlorate(I).

(Total for Question = 1 mark)

26 Platinum forms a complex with the formula $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ and chromium forms a complex ion with the formula CrCl_4^- .

(a) Considering the shapes of these complexes,

(1)

- A both complexes are square planar.
- B both complexes are tetrahedral.
- C $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ is tetrahedral and CrCl_4^- is square planar.
- D $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ is square planar and CrCl_4^- is tetrahedral.

(b) Considering the structures of these complexes,

(1)

- A both complexes form stereoisomers.
- B neither complex forms a stereoisomer.
- C $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ forms a stereoisomer but CrCl_4^- does not.
- D CrCl_4^- forms a stereoisomer but $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ does not.

(c) Considering the bonding between the central atom and the ligands in these complexes,

(1)

- A the bonding in both complexes is dative covalent.
- B the bonding in both complexes is ionic.
- C the bonding in $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ is dative covalent and in CrCl_4^- is ionic.
- D the bonding in $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ is ionic and in CrCl_4^- is dative covalent.

(Total for Question = 3 marks)

27 The transition metal complex $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ exists as two geometric isomers. This is because the complex

- A is square-planar.
- B is tetrahedral.
- C contains a double bond.
- D is octahedral.

(Total for Question 1 mark)

28 A hydrated transition metal ion is colourless. Which of the following could be the electronic configuration of this ion?

- A $[\text{Ar}] 3d^5 4s^2$
- B $[\text{Ar}] 3d^8$
- C $[\text{Ar}] 3d^{10} 4s^2$
- D $[\text{Ar}] 3d^{10}$

(Total for Question 1 mark)

29 Which of the following species is **not** able to act as a ligand in the formation of transition metal complexes?

- A $\text{C}_6\text{H}_5\text{NH}_2$
- B NH_3
- C $\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
- D NH_4^+

(Total for Question 1 mark)

30 The element zinc, with electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$, is **not** regarded as a transition element because

- A the oxide of zinc is amphoteric.
- B none of its ions has an unpaired electron in the *d*-subshell.
- C it does not readily form complex ions.
- D it has a boiling temperature low enough for it to be easily distilled.

(Total for Question 1 mark)

31 What type of bonding occurs between the metal ion and ligand in the complex ion $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$?

- A Metallic
- B Ionic
- C Hydrogen
- D Dative covalent

(Total for Question 1 mark)