Reactions and Applications of Transition Metals

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Transition Metals & Organic Nitrogen Chemistry
Sub Topic	Reactions and Applications of Transition Metals
Booklet	Question Paper 1

Time Allowed: **29 minutes**

Score: **/24**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 The following complexes have different shapes.

A $[Ag(NH_3)_2]^+$

B $[CrCl_4]^-$

C $[Ni(H_2NCH_2CH_2NH_2)_3]^{2+}$

D $[Pt(NH_3)_2Cl_2]$

(a) Which complex is square-planar?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which complex has geometric isomers?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 2 marks)

2 What are the colours of the complex ions formed by copper(II) ions with butylamine and chloride ions?

	$[Cu(C_4H_9NH_2)_4(H_2O)_2]^{2+}$	$[CuCl_4]^{2-}$
☒ **A**	blue	yellow
☒ **B**	blue	green
☒ **C**	yellow	blue
☒ **D**	yellow	green

(Total for Question 2 = 1 mark)

3 Iron(III) ions form a more stable complex with EDTA than with water. What is the **best** explanation for this?

☒ **A** Iron(III) ions form stronger bonds with EDTA than with water.

☒ **B** Iron(III) ions form more bonds with EDTA than with water.

☒ **C** ΔS_{system} is positive for the formation of the EDTA complex from $[Fe(H_2O)_6]^{3+}$.

☒ **D** $\Delta H_{reaction}$ is positive for the formation of the EDTA complex from $[Fe(H_2O)_6]^{3+}$.

(Total for Question 3 = 1 mark)

4 What is the order of **increasing** reducing power of the ions Cr^{2+}, Fe^{2+} and V^{2+}?
Use items 20, 54 and 26 on pages 14 and 15 of your Data Booklet.

☒ **A** V^{2+}, Cr^{2+}, Fe^{2+}.

☒ **B** Cr^{2+}, V^{2+}, Fe^{2+}.

☒ **C** Fe^{2+}, V^{2+}, Cr^{2+}.

☒ **D** Fe^{2+}, Cr^{2+}, V^{2+}.

(Total for Question 4 = 1 mark)

5 Hydrated chromium(III) chloride, $CrCl_3.6H_2O$, exists in several isomeric forms with varying numbers of chloro and water ligands.

A solution containing 0.10 mol of one of these isomers reacts with excess silver nitrate. 0.20 mol of silver chloride, AgCl, is precipitated immediately.
The formula of the complex ion in this isomer is

☒ **A** $[Cr(H_2O)_6]^{3+}$

☒ **B** $[CrCl(H_2O)_5]^{2+}$

☒ **C** $[CrCl_2(H_2O)_4]^{+}$

☒ **D** $[CrCl_3(H_2O)_3]$

(Total for Question 5 = 1 mark)

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6 A solution is prepared for use in the standard half cell $Fe^{3+}(aq), Fe^{2+}(aq)|Pt$.

What is the mole ratio of the solids iron(II) sulfate, $FeSO_4$, and iron(III) sulfate, $Fe_2(SO_4)_3$, which should be dissolved to make the solution for this cell?

☒ **A** 2:1

☒ **B** 1:1

☒ **C** 1:2

☒ **D** 3:2

(Total for Question 6 = 1 mark)

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7 Copper reacts with nitrate ions, NO_3^-, in acid conditions to form copper(II) ions and nitrogen(IV) oxide.

By considering the changes in the oxidation numbers of copper and nitrogen, it can be deduced that the redox reaction involves

☒ **A** 1 mol of copper reacting with 2 mol of nitrate ions.

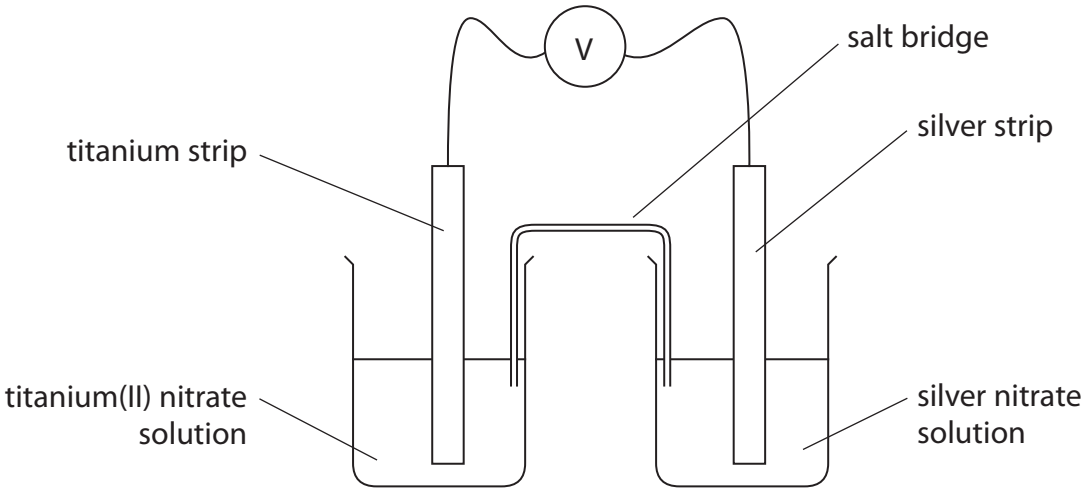
☒ **B** 2 mol of copper reacting with 1 mol of nitrate ions.

☒ **C** 1 mol of copper reacting with 4 mol of nitrate ions.

☒ **D** 4 mol of copper reacting with 1 mol of nitrate ions.

(Total for Question 7 = 1 mark)

8 The cell shown in the diagram below was set up.



The emf of this cell under standard conditions is +2.43 V.
The $E^{\ominus}$ value for the $Ag^{+}(aq)|Ag(s)$ half cell is +0.80 V.

What is the $E^{\ominus}$ value for the $Ti^{2+}(aq)|Ti(s)$ half cell?

☒ **A** +3.23 V

☒ **B** +1.63 V

☒ **C** –1.63 V

☒ **D** –3.23 V

(Total for Question 8 = 1 mark)

9 Which of the following species **never** combine with ligands to form complexes?

☒ **A** Positively charged ions of d block elements.

☒ **B** Neutral atoms of d block elements.

☒ **C** Negatively charged ions of d block elements.

☒ **D** Positively charged ions of p block elements.

(Total for Question 9 = 1 mark)

10 Transition metal complexes are formed when ethanedioate ions and ethanoate ions are added separately to aqueous solutions of transition metal ions.

The complexes formed by the bidentate ethanedioate ligands are more stable than the complexes formed by the monodentate ethanoate ligands. This is because

- ☒ **A** ethanedioate ligands form stronger bonds with the metal ion of a complex than do ethanoate ligands.
- ☒ **B** the formation of ethanedioate complexes increases the number of particles in the solution.
- ☒ **C** ethanedioic acid is a stronger acid than ethanoic acid.
- ☒ **D** ethanedioic acid is a weaker acid than ethanoic acid.

(Total for Question 10 = 1 mark)

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11 Which of the following is correct for the standard hydrogen electrode?

- ☒ **A** The temperature is kept at 273 K.
- ☒ **B** Sulfuric acid with a concentration of 0.5 mol dm^{-3} is used.
- ☒ **C** The metal electrode is copper foil.
- ☒ **D** The hydrogen pressure is 1 atmosphere.

(Total for Question 11 = 1 mark)

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12 The standard electrode potentials of two electrode systems are given below.

$$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s) \qquad E^{\ominus} = -0.74\ V$$

$$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s) \qquad E^{\ominus} = -0.40\ V$$

Calculate the $E^{\ominus}_{cell}$ for the reaction

$$2Cr(s) + 3Cd^{2+}(aq) \rightarrow 3Cd(s) + 2Cr^{3+}(aq)$$

☒ **A** −0.34 V

☒ **B** +0.34 V

☒ **C** −0.28 V

☒ **D** +0.28 V

(Total for Question 12 = 1 mark)

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13 The calculated $E^{\ominus}$ for a reaction is positive but no reaction occurs when the reagents are mixed under standard conditions. It can be deduced that

☒ **A** the reaction is thermodynamically feasible and the reaction mixture is kinetically stable.

☒ **B** the reaction is thermodynamically feasible and the reaction mixture is kinetically unstable.

☒ **C** the reaction mixture is thermodynamically and kinetically stable.

☒ **D** the reaction mixture is thermodynamically stable and kinetically unstable.

(Total for Question 13 = 1 mark)

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14 When dilute aqueous ammonia is added to an aqueous solution of a metal ion, a green precipitate is formed which dissolves slowly in excess ammonia to form a green solution. What is the metal ion present in the original solution?

☒ **A** Ni^{2+}

☒ **B** Fe^{2+}

☒ **C** Cu^{2+}

☒ **D** Cr^{3+}

(Total for Question 14 = 1 mark)

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15 The standard reduction potential of the system

$$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$$

is $E^{\ominus} = +0.15$ V.

(a) What are the components of the half-cell required to measure the standard reduction potential of this system?

(1)

	Ion(s) in the solution	Metal electrode
☒ **A**	Sn^{2+}	tin
☒ **B**	Sn^{4+}	tin
☒ **C**	Sn^{2+} and Sn^{4+}	tin
☒ **D**	Sn^{2+} and Sn^{4+}	platinum

(b) A standard $[Sn^{4+}(aq)]$, $[Sn^{2+}(aq)]$ half cell is connected to a standard hydrogen electrode. At the hydrogen electrode

(1)

☒ **A** hydrogen gas is oxidized to hydrogen ions.

☒ **B** hydrogen ions are oxidized to hydrogen gas.

☒ **C** hydrogen gas is reduced to hydrogen ions.

☒ **D** hydrogen ions are reduced to hydrogen gas.

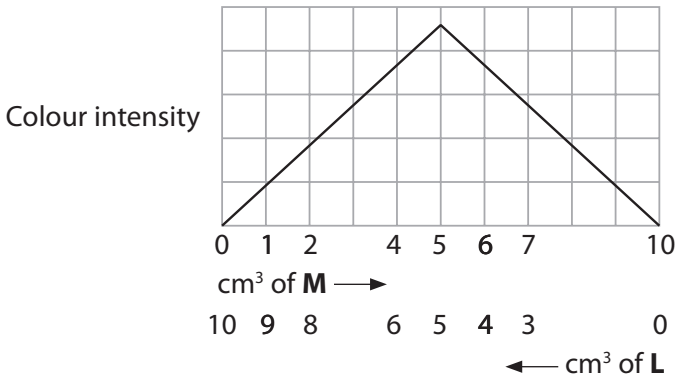
(Total for Question 15 = 2 marks)

16 A transition metal ion, **M**, reacts with a complexing agent, **L**, to form a coloured complex with the formula $\mathbf{ML_2}$.

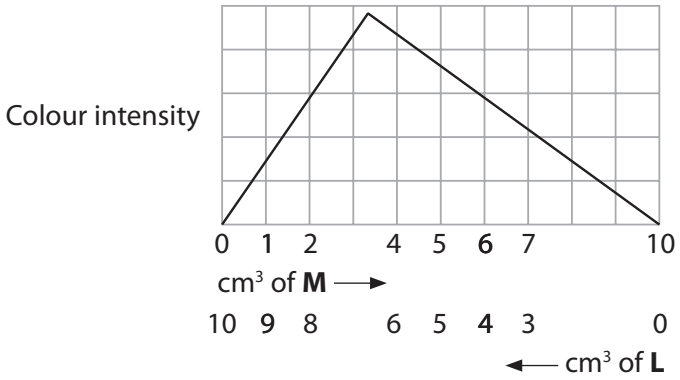
Portions of a 0.05 mol dm^{-3} solution of **M** were mixed with portions of a 0.05 mol dm^{-3} solution of **L**, so that the total volume of the resulting mixture was always 10 cm^3. The colour intensities of the complex in these mixtures were measured using a colorimeter.

What would the graph of the results look like?

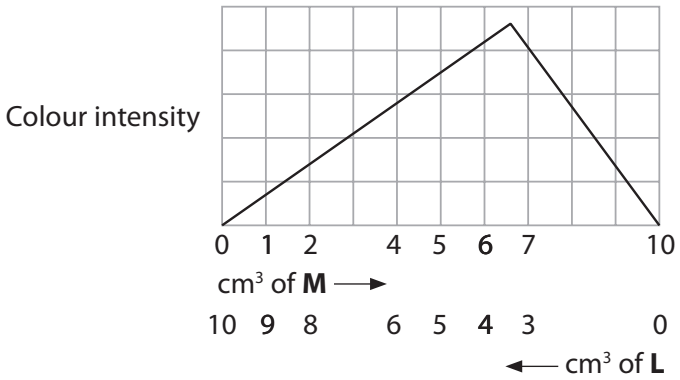
☒ **A**



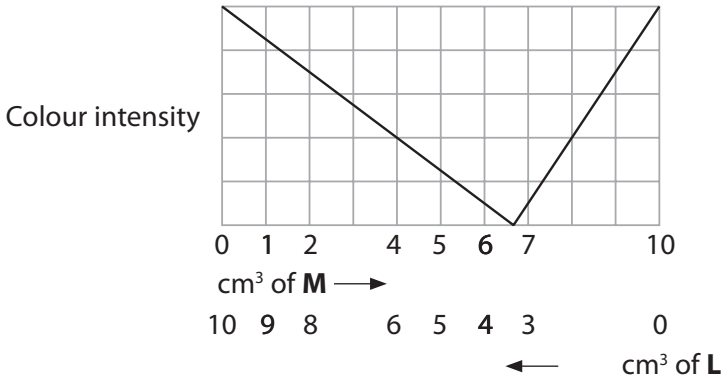
☒ **B**



☒ **C**



☒ **D**



(Total for Question 16 = 1 mark)

17 When concentrated hydrochloric acid is added to an aqueous solution of copper(II) sulfate, the blue solution changes to green then yellow. The change in colour is due to

☒ **A** the formation of chlorine in the solution.

☒ **B** the gradual replacement of the sulfate ion ligands by chloride ions.

☒ **C** the gradual replacement of the water ligands by chloride ions.

☒ **D** the reduction of the copper(II) ions to copper(I) ions.

(Total for Question 17 = 1 mark)

18 Dilute hydrochloric acid and dilute aqueous sodium hydroxide are added in excess to separate samples of chromium(III) hydroxide. What would be observed?

	Addition of HCl(aq)	Addition of NaOH(aq)
☒ **A**	green solution	green solution
☒ **B**	green solution	green solid
☒ **C**	green solid	green solution
☒ **D**	green solid	green solid

(Total for Question 18 = 1 mark)

19 Which of the following is **not** a redox reaction?

☒ **A** $3CrCl_2 + Na_2CrO_4 + 8HCl \rightarrow 4CrCl_3 + 4H_2O + 2NaCl$

☒ **B** $2MnO_4^{2-} + C_8H_7O_3^- + 2OH^- \rightarrow 2MnO_4^{3-} + C_8H_5O_3^- + 2H_2O$

☒ **C** $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

☒ **D** $MnO_4^- + 3H_2SO_4 \rightarrow MnO_3^+ + H_3O^+ + 3HSO_4^-$

(Total for Question 19 = 1 mark)

20 The standard reduction potentials of two systems are given below.

$$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) \qquad E^{\ominus} = +0.34\,V$$

$$Ag^{+}(aq) + e^- \rightleftharpoons Ag(s) \qquad E^{\ominus} = +0.80\,V$$

What is $E^{\ominus}_{cell}$ for the reaction between copper and silver nitrate?

$$Cu(s) + 2Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$$

☒ **A** −1.26 V

☒ **B** −0.46 V

☒ **C** +0.46 V

☒ **D** +1.26 V

(Total for Question 20 = 1 mark)

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21 A cell is set up with two metal-metal ion half cells and the digital voltmeter reads zero. Given that all the components of the cell have been included and are working properly, what is the most likely explanation for the zero reading?

☒ **A** The cell has been set up the wrong way round.

☒ **B** The entropy change, $\Delta S_{system} = 0$.

☒ **C** The activation energy for the reaction is very high.

☒ **D** The reaction system is at equilibrium.

(Total for Question 21 = 1 mark)

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22 A compound, **X**, is dissolved in water. Sodium hydroxide solution and dilute aqueous ammonia were added to different samples of this solution of **X**. In both, a precipitate formed which dissolved in excess reagent. Compound **X** could be

☒ **A** copper(II) sulfate.

☒ **B** iron(II) sulfate.

☒ **C** manganese(II) sulfate.

☒ **D** zinc(II) sulfate.

(Total for Question 22 = 1 mark)
