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A' Level Chemistry

Year 2

Unit 17: Transition Metals

Summer Examination Revision Pack

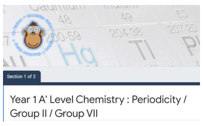
The questions in this pack should be attempted **AFTER** completing all other revision.

Grade Accelerator
Recall Definitions
Drawing Diagrams
Using Equations
Drawing Graphs

Quizlet

Quizlet Classes
Flashcard Based
Games
Tests & Quizzes
Keyword Spell Checker

Condensed Notes
Keywords & Definitions
Key Concepts
Application
Key Skills



Online Forms
Take Time to Answer
Use Paper & Calculator
Work It Out
Review Missed Marks

Use the 3 Wave Process when completing these revision packs.

1. Complete the questions without assistance
(Can't answer a question? Leave it and move on)
2. Use your notes to fill any gaps after step 1
3. Use the mark scheme to fill in any remaining gaps.

1. Having gaps after step 1 is normal, that's why we are doing revision!
2. If your notes don't help during step 2, they are not good enough!
(Change your note taking method and try to understand the problem)
3. If you don't understand why the mark scheme answer is correct, **see Andy.**

STOP If you struggle with the questions in the pack, **STOP!** and complete some more revision.

STOP If you come to a complete dead-end, **STOP!** and speak to **Andy** asap.

Do not write outside the box

1 1 This question is about compounds containing ethanedioate ions.

1 1 . 1 A white solid is a mixture of sodium ethanedioate ($Na_2C_2O_4$), ethanedioic acid dihydrate ($H_2C_2O_4.2H_2O$) and an inert solid. A volumetric flask contained 1.90 g of this solid mixture in 250 cm^3 of aqueous solution.

Two different titrations were carried out using this solution.

In the first titration 25.0 cm^3 of the solution were added to an excess of sulfuric acid in a conical flask. The flask and contents were heated to 60 °C and then titrated with a 0.0200 mol dm^{-3} solution of potassium manganate(VII). When 26.50 cm^3 of potassium manganate(VII) had been added the solution changed colour.

The equation for this reaction is

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$$

In the second titration 25.0 cm^3 of the solution were titrated with a 0.100 mol dm^{-3} solution of sodium hydroxide using phenolphthalein as an indicator. The indicator changed colour after the addition of 10.45 cm^3 of sodium hydroxide solution.

The equation for this reaction is

$$H_2C_2O_4 + 2OH^- \rightarrow C_2O_4^{2-} + 2H_2O$$

Calculate the percentage by mass of sodium ethanedioate in the white solid.

Give your answer to the appropriate number of significant figures.
Show your working.

[8 marks]

Percentage by mass of sodium ethanedioate ____________________ %

1 1 . 2 Ethanedioate ions react with aqueous iron(III) ions in a ligand substitution reaction.

Write an equation for this reaction.

Suggest why the value of the enthalpy change for this reaction is close to zero.

[2 marks]

1 1 . 3 Draw the displayed formula of the iron complex produced in the reaction in Question **11.2**

Indicate the value of the O—Fe—O bond angle.

State the type of isomerism shown by the iron complex.

[3 marks]

Bond angle

Type of isomerism

1 1 . 4 Ethanedioate ions are poisonous because they react with iron ions in the body. Ethanedioate ions are present in foods such as broccoli and spinach.

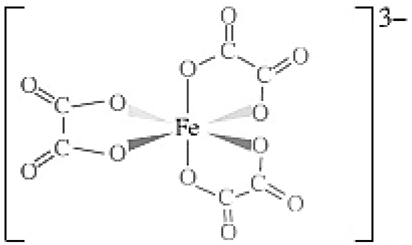
Suggest one reason why people who eat these foods do not suffer from poisoning.

[1 mark]

END OF QUESTIONS

14

Question	Answers	Mark	Additional Comments/Guidance
11.1	Moles MnO_4^- $\frac{26.50 \times 0.02}{1000} = 5.30 \times 10^{-4}$	1	The first CE is penalised by 2 marks; further errors are penalised by one mark each
	Moles in 25cm^3 sample / pipette $C_2O_4^{2-}$ (from acid and salt) = 5.30 x 10^{-4} **<u>x 5/2</u>** = (1.325 x 10^{-3})	1	M2 = M1 x 5/2
	Moles NaOH = $\frac{10.45 \times 0.1}{1000}$ (= 1.045 × 10^{-3})	1	
	So moles $C_2O_4^{2-}$ from acid in 25cm^3 sample / pipette = 1.045 x 10^{-3} **<u>÷ 2</u>** = 5.225 x 10^{-4}	1	M4 = M3 ÷ 2
	Hence moles $C_2O_4^{2-}$ in sodium ethanedioate in 25 cm^3 = 1.325 x 10^{-3} – 5.225 x 10^{-4} (= 8.025x 10^{-4})	1	M5 = M2 – M4 (do not allow if negative and do not allow = M4-M2) **If no subtraction, max = 5 (M1, M2, M3, M4 and M6)** **If incorrect subtraction, max = 6 (M1, M2, M3, M4, M6 and M7)**
	So moles $C_2O_4^{2-}$ in sodium ethanedioate in original sample = 8.025x 10^{-4} **<u>x 10</u>** (= 8.025x 10^{-3})	1	M6 = M5 x 10 (M6 can be scored by multiplying M2 <u>and</u> M4 by 10 before subtraction (giving 1.325x10^{-2} – 5.225x10^{-3} = 8.025x10^{-3})
	Mass $Na_2C_2O_4$= 8.025x10^{-3} **<u>x 134(.0)</u>** = 1.075(35) g	1	M7 = M6 x 134
	So % sodium ethanedioate in original sample $\frac{1.075(35)}{1.90} \times 100$ = 56.6 % to 3 sig fig	1	M8 = (M7/1.90)x100 Allow 56.5 – 56.8%

Question	Answers	Mark	Additional Comments/Guidance
11.2	$[Fe(H_2O)_6]^{3+}$ + $3C_2O_4^{2-}$ → $[Fe(C_2O_4)_3]^{3-}$ + $6H_2O$ There are 6 Fe –O bonds broken and then made / same number and type of bond being broken and made.	1 1	
11.3	 90° or 180° optical	1 1 1	Ignore all charges even if wrong Ignore absence of square brackets Candidates do not need to show 3D shape
11.4	The ethanedioic acid is only present in small quantities/low concentration in these foods.	1	
Total		**14**	

Do not write outside the box

0 9 This question is about vanadium compounds and ions.

0 9 . 1 Use data from **Table 4** to identify the species that can be used to reduce VO_2^+ ions to VO^{2+} in aqueous solution and no further.
Explain your answer.

Table 4

Electrode half-equation	$E^\ominus$ / V
$VO_2^+(aq) + 2H^+(aq) + e^- \rightarrow VO^{2+}(aq) + H_2O(l)$	+1.00
$VO^{2+}(aq) + 2H^+(aq) + e^- \rightarrow V^{3+}(aq) + H_2O(l)$	+0.34
$Cl_2(aq) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76

[2 marks]

Reagent ______________________________

Explanation ______________________________

____

____

0 9 . 2 Give the oxidation state of vanadium in $[VO(H_2O)_5]^{2+}$

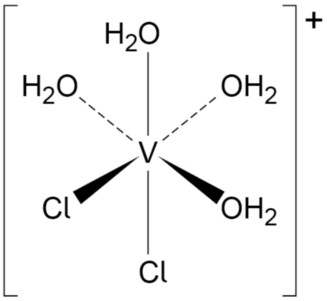
[1 mark]

____

0 9 . 3 The $[V(H_2O)_4Cl_2]^+$ ion exists as two isomers. One isomer is shown.

Draw the structure of the other isomer and state the type of isomerism.

[2 marks]



Type of isomerism ____________________

0 9 . 4 Heating NH_4VO_3 produces vanadium(V) oxide, water and one other product.

Give an equation for the reaction.

[1 mark]

____

0 9 . 5 Vanadium(V) oxide is the catalyst used in the manufacture of sulfur trioxide.

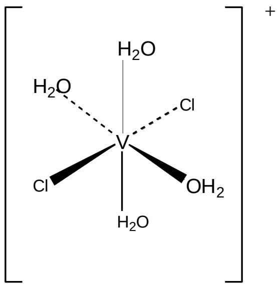
Give **two** equations to show how the catalyst is used and regenerated.

[1 mark]

____

____

7

Question	Answers	Additional Comments/Guidance	Mark
09.1	Fe^{2+} $E^{\ominus}$ VO_2^{+}(/ VO^{2+}) > $E^{\ominus}$ Fe^{3+}(/Fe^{2+}) > $E^{\ominus}$ VO^{2+}(/V^{3+})	Accept any Fe(II) compound – correct formula or name If calculations of EMF are provided producing EMFs = 0.23(V) and -0.43(V), with a comment, allow M2 allow $E^{\ominus}$ Fe^{3+} (/Fe^{2+}) value of +0.77 is between the $E^{\ominus}$ values for the electrode half-equations containing the V species or wtte	1 1
09.2	(+) 4	IV or four	1
09.3	 Cis/trans	Ignore absence of charge Wedges, dotted lines and [ ] not required Do not penalise bond from H to V (in water ligands) allow E/Z, geometric and stereo(isomerism)	1 1
09.4	2 NH_4VO_3 → V_2O_5 + H_2O + $2NH_3$	Accept multiples Ignore state symbols	1
09.5	V_2O_5 + SO_2 → V_2O_4 + SO_3 V_2O_4 + ½ O_2 → V_2O_5	Both equations needed for 1 mark in this order Allow multiples	1

Total			7

Do not write outside the box

0 7 Copper(II) complexes are coloured.
The colour is caused by the d electrons of copper moving from their ground state to an excited state.

0 7 . 1 Explain why aqueous solutions containing $[CuCl_4]^{2-}$ ions are yellow.

[2 marks]

____

____

____

____

____

0 7 . 2 When a d electron moves from the ground state to the excited state in a copper complex, the energy change is 3.98×10^{-19} J

The Planck constant, $h = 6.63 \times 10^{-34}$ J s

Calculate the frequency, in s^{-1}, of the light absorbed.

[2 marks]

Frequency ____________________ s^{-1}

0 7 . 3 State **three** ways in which a transition metal complex can be changed to alter its colour.

[3 marks]

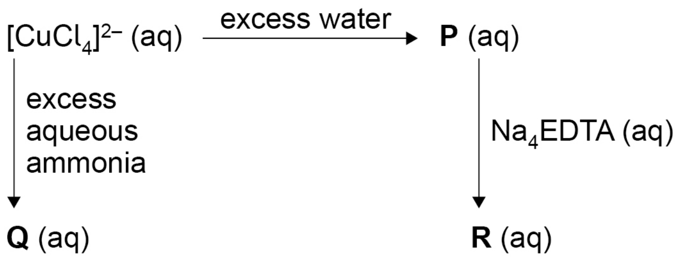
1 ____

2 ____

3 ____

Question 7 continues on the next page

Consider the following reaction scheme in which **P**, **Q** and **R** are different complex ions of copper.



0 7 . 4 Name the shape of the $[CuCl_4]^{2-}$ ion.

[1 mark]

---

0 7 . 5 Give an ionic equation for the conversion of $[CuCl_4]^{2-}$ to complex ion **P**.

[1 mark]

---

0 7 . 6 State the colour of the solution containing the complex ion **Q**.

Give an ionic equation for the conversion of $[CuCl_4]^{2-}$ to **Q**.

[2 marks]

Colour ______________________________

Equation

---

0 7 . 7 Identify complex ion **R**.

[1 mark]

12

Question	Answers	Additional Comments/Guidelines	Mark
07.1	(visible/white) light <u>absorbed</u> (and (d) electrons excited) only yellow light transmitted/reflected	do **not** accept absorbs yellow light do **not** accept emitted reference to light required in M1 or M2	1 1 AO2

Question	Answers	Additional Comments/Guidelines	Mark
07.2	$(\Delta)E = h\nu$ **or** $\frac{hc}{\lambda}$ $6(.00) \times 10^{14}$ (s^{-1})	allow with **or** without numbers	1 1 AO2

Question	Answers	Additional Comments/Guidelines	Mark
07.3	(change in) oxidation state (of metal) (change of) ligand (change in) co-ordination number	 allow (change the) number of ligands	1 1 1 AO1

Question	Answers	Additional Comments/Guidelines	Mark
07.4	tetrahedral	allow tetrahedron	1 AO3

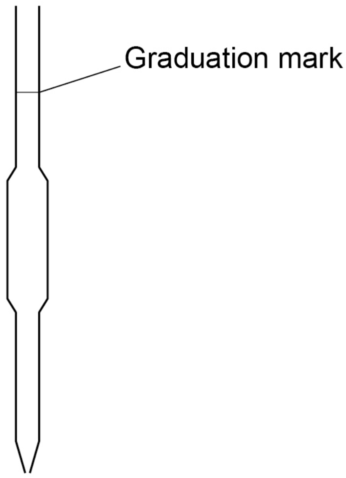
Question	Answers	Additional Comments/Guidelines	Mark
07.5	$[CuCl_4]^{2-} + 6\,H_2O \rightarrow [Cu(H_2O)_6]^{2+} + 4\,Cl^-$		1 AO3

Question	Answers	Additional Comments/Guidelines	Mark
07.6	deep blue $[CuCl_4]^{2-} + 4\,NH_3 + 2\,H_2O \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4\,Cl^-$	allow dark blue	1 1 AO3

Question	Answers	Additional Comments/Guidelines	Mark
07.7	$[Cu(EDTA)]^{2-}$	ignore absence of brackets	1 AO3

0 1 . 4 **Figure 1** shows the 25.0 cm^3 pipette used to measure the sodium ethanedioate solution.

Figure 1



On **Figure 1**, draw the meniscus of the solution when the pipette is ready to transfer 25.0 cm^3 of the sodium ethanedioate solution.

[1 mark]

0 1 . 5 Potassium manganate(VII) is oxidising and harmful.
Sodium ethanedioate is toxic.

Suggest safety precautions, other than eye protection, that should be taken when:

- filling the burette with potassium manganate(VII) solution
- dissolving the solid sodium ethanedioate in water.

[2 marks]

Filling the burette ____

____

Dissolving the solid ____

____

0 1 . 6 State the colour change seen at the end point of each titration.

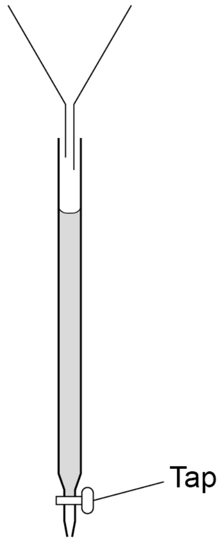
[1 mark]

____

Do not write outside the box

0 1 . 7 **Figure 2** shows the burette containing potassium manganate(VII) solution.

Figure 2



Give **two** practical steps needed before recording the initial burette reading.

[2 marks]

1 ____

2 ____

Question 1 continues on the next page

Do not write outside the box

0 1 . 8 When $Na_2C_2O_4(aq)$ is added to a solution containing $[Fe(H_2O)_6]^{3+}$ ions, a reaction occurs in which all six water ligands are replaced by ethanedioate ions.

Explain why the replacement of the water ligands by ethanedioate ions is favourable. In your answer refer to:

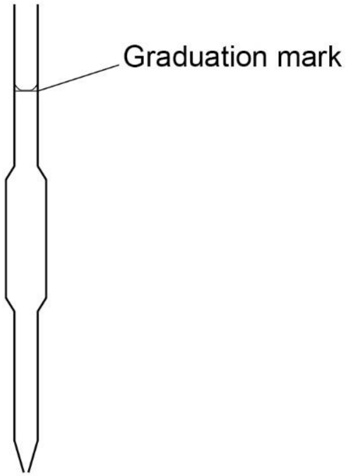
- the enthalpy and entropy changes for the reaction
- how the enthalpy and entropy changes influence the free-energy change for the reaction.

[6 marks]

Do not write outside the box

20

Turn over for the next question

Question	Answers	Additional comments/Guidelines	Mark
1.4		Meniscus <u>curved</u> with the bottom of the curve on the horizontal line	1

Question	Answers	Additional comments/Guidelines	Mark
1.5	(burette) fill below/at eye level	**ignore** make sure tap closed / funnel / gloves	1
	(solution) wear gloves	**allow** wash/rinse hands after any spillage **not** fume cupboard **ignore** lab coat / stir carefully	1

Question	Answers	Additional comments/Guidelines	Mark
1.6	colourless to pink/pale purple	**not** just purple **not** ‘clear’ for ‘colourless’	1

Question	Answers	Additional comments/Guidelines	Mark
1.7	remove funnel ensure jet is filled / no (air) bubbles	 **allow** open tap to fill space below tap	1 1

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th></tr>
<tr><td>1.8</td><td>
<table>
<tr><td colspan="2">This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.</td></tr>
<tr><td>Level 3
5-6 marks</td><td>All stages are covered and each stage is generally correct and virtually complete.
Answer is communicated coherently and shows a logical progression from Stage 1 to Stages 2 and 3
Covers at least 2 point for stage 1, 1 for stage 2 and 2 for stage 3.
If given equation must show correct stoichiometry for six marks</td></tr>
<tr><td>Level 2
3-4 marks</td><td>All stages are covered but stage(s) may be incomplete or may contain inaccuracies
OR two stages are covered and are generally correct and virtually complete.
Answer is communicated mainly coherently and shows a logical progression from Stage 1 to Stages 2 and 3.</td></tr>
<tr><td>Level 1
1-2 marks</td><td>Two stages are covered but stage(s) may be incomplete or may contain inaccuracies
OR only one stage is covered but is generally correct and virtually complete.
Answer includes isolated statements but these are not presented in a logical order.</td></tr>
<tr><td>0 mark</td><td>Insufficient correct chemistry to gain a mark.</td></tr>
</table>
</td><td>
Stage 1 - ΔH
1a ΔH negligible
1b make & break same number of bonds
1c make & break same type of bonds / bonds have similar enthalpies

Stage 2 - ΔS
2a increase in entropy
2b increase in particles in solution / from 4 to 7 particles (ecf from incorrect equation showing increase in no. of moles)

Stage 3 - ΔG
3a ΔG = ΔH –TΔS
3b ΔG negative (for forward reaction)
3c correct discussion of why ΔG is negative based on ΔH and TΔS
</td><td>6</td></tr>
</table>