GCE

Chemistry A

H432/01: Periodic table, elements and physical chemistry

A Level

Mark Scheme for June 2025

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training: OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone or the RM Assessor messaging system, or by email.

5. **Crossed Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

   Rubric Error Responses – Optional Questions
   Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses
When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)
   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).
   Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

8. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by **levels of response**:
Read through the whole answer from start to finish, using the Level descriptors to help you decide whether it is a strong or weak answer. The indicative scientific content in the Guidance column indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the skills and science content evidenced within the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.

Once the level is located, award the higher or lower mark:

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

The skills and science content determines the level.

The communication statement determines the mark within a level.

Level of response questions on this paper are **16(d)*** and **19(c)*.**

The only annotation on a level of response question should be the indication of the level.

A level annotation should be used where all marks for a level have been achieved e.g. a candidate has 6 marks, so they would have this annotation on their script:

L3

If a candidate has achieved 5 marks then they have reached Level 3 but with one mark omitted. They should have the following annotations on their scripts:

L3 ^

The same principle should be applied to Level 2 and Level 1.

No marks (0) should have a cross: ✗

Place the annotations alongside the mark for the question.

On additional pages, annotate using SEEN

11. **Annotations**

Annotation	Meaning
✓	Correct response
✗	Incorrect response
^	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given

Annotation	Meaning
I	Ignore
BP	Blank page

12. **Subject Specific Marking Instructions**

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/; OR	alternative and acceptable answers for the same marking point
✓	Separates marking points
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

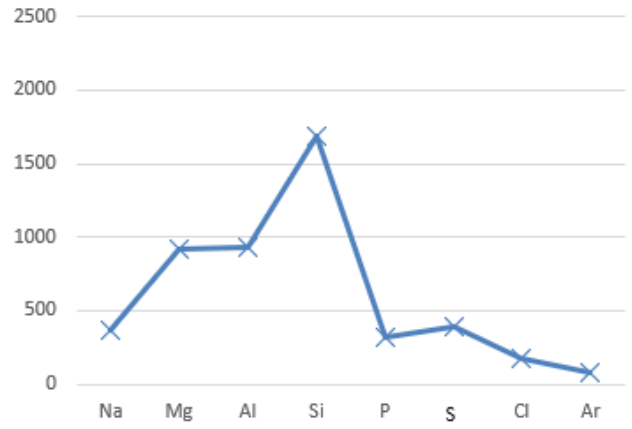
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

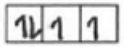
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

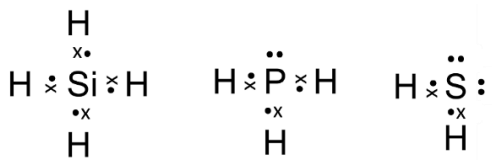
SECTION A

Question	Answer	Marks	Guidance
1	C	1	
2	C	1	
3	B	1	
4	A	1	
5	B	1	
6	C	1	
7	C	1	
8	D	1	
9	B	1	
10	C	1	
11	B	1	
12	C	1	
13	C	1	
14	B	1	
15	B	1	
		15	

SECTION B

Question			Answer	Mark	Guidance
16	(a)	(i)	S higher than P **AND** P higher than Cl **AND** Cl higher than Ar ✓ All points / line below the height of Mg ✓	2	
		(ii)	Al **giant** (metallic) **AND** Si **giant** (covalent) ✓ Al metallic **AND** Si covalent ✓ Covalent bonds (in Si) strong**er** / more energy needed to break covalent bonds (than metallic in Al) ✓	3	**ALLOW** macromolecular for Si **ALLOW** correct description of each bonding type **CON** if intermolecular forces are compared in Al

Question			Answer	Mark	Guidance
	(b)	(i)	S**(g)** → S^+**(g)** + e^- ✓	1	**IGNORE** state symbols on the electron
		(ii)	Paired electrons in (p-) orbital / sub shell (in S) ✓ Repulsion (between the paired electrons) ✓	2	**ALLOW** if seen in a diagram i.e.  **ALLOW** 2 electrons in an (p-) <u>orbital</u> **DO NOT ALLOW** shell alone **DO NOT ALLOW** s-orbital **IGNORE** distance from nucleus
	(c)		(aqueous bromine + sodium iodide) (Orange solution) **turns** brown ✓ (aqueous bromine + sodium chloride) **Stays** orange ✓ $Br_2 + 2I^- \rightarrow 2Br^- + I_2$ ✓	3	**ALLOW** one mark for only final colours **ALLOW** shade of brown for dilute I_2 **DO NOT ALLOW** purple **DO NOT ALLOW** incorrect colour for aqueous bromine **ALLOW** shade of orange for dilute Br_2 **ALLOW** No colour change **IGNORE** No reaction / No change **DO NOT ALLOW** *<u>turns</u>* orange **ALLOW multiples,** e.g. $\frac{1}{2}Br_2 + I^- \rightarrow Br^- + \frac{1}{2}I_2$ **IGNORE** state symbols **IGNORE** half-equations, even if wrong

Question	Answer	Mark	Guidance
(d)*	**Level 3 (5–6 marks)** For all three molecules: correct dot and cross diagrams drawn **AND** correct shapes **AND** correct trend of bond angles **AND** an explanation of electron pair repulsion on shape *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** For two molecules: correct dot and cross diagrams drawn **AND** correct shapes **AND** correct trend of bond angles **AND** an explanation of electron pair repulsion on shape **OR** For all three molecules: One correct and three *attempts* from: dot cross diagrams shapes trend in bond angles explanation of electron pair repulsion on the shapes *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*	6	**Indicative scientific points may include:** **Dot and cross diagrams**  **Shapes** SiH_4 tetrahedral PH_3 (trigonal) pyramidal H_2S v-shaped / bent / angular / non-linear **IGNORE** planar / 'not straight' **Trend of bond angles** Bond angles in the order (numerical bond angles are not required) $SiH_4 > PH_3 > H_2S$ $SiH_4 = 109.5^o >$ PH_3 (less than 109.5) > H_2S (less than PH_3) > 90° **Explanation of bond angles** SiH_4 Four bonding pairs (no lone pairs) PH_3 Three bonding pairs one lone pair H_2S Two bonding pairs two lone pairs Electron pairs repel Lone pairs repel more than bonding pairs **ALLOW** lp for lone pair (of electrons) **ALLOW** bp for bonding pair (of electrons) **ALLOW** regions for electron pairs (electron pairs seen in diagram) **IGNORE** electron density **IGNORE** 'bonds' for 'bonded pair' **IGNORE** 'electrons repel' **DO NOT ALLOW** 'atoms repel'

Question			Answer	Mark	Guidance
			Level 1 (1–2 marks) For one molecule: correct dot and cross diagram drawn **AND** correct shape **AND** an explanation of electron pair repulsion on shape or any molecule **OR** For two molecules: correct dot and cross diagrams **OR** correct shapes **OR** an explanation of electron pair repulsion on shape *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		

Question			Answer	Mark	Guidance
17	(a)	(i)	Iron is an element (in its standard state) ✓	1	Takes no energy to make an element from an element (under standard conditions)
		(ii)	(ΔH =) 3(–394) + 0 – (–824) – 3(–111) ✓ (ΔH =) –25 kJ mol^{-1} ✓	2	**ALLOW ECF** for one transcriptional error **Common Errors** 1 mark (+) 763 (no 3 x –394) (+) 25 (incorrect sign) –247 (no 3 x –111) –2339 (+ for – (–824 + 3 x –111))
		(iii)	Fe_2O_3 is a solid and CO_2 is a gas ✓ So CO_2 / gas more disordered **OR** greater number of ways a system can be arranged / energy can be dispersed in CO_2 / gas ✓	2	**ALLOW ORA**
		(iv)	15 = 3(214) + 2x – 87 – 3(198) **OR** 54✓ (2x = 54 so) S = 27 (J K^{-1} mol^{-1}) ✓	2	**ALLOW ECF** for a calculated value using all numerical values **Common Errors** *1 mark* *241 (No 3 x 214)* *12 (Subtraction backwards)* *–171 (No 3 x198)*

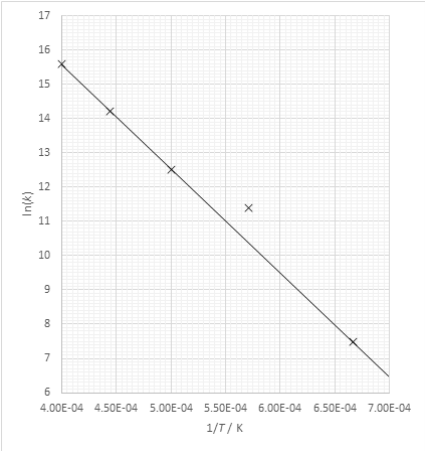
Question			Answer	Mark	Guidance
	(b)		***ΔG at 100°C*** ($\Delta G = \Delta H - T\Delta S$ = 491 – (373 × 0.543) / 491000 – (373 × 543)) = (+) 288 (kJ mol^{-1}) **OR** (+) 288461 (J mol^{-1}) ✓ **Feasibility statement** Not feasible when $\Delta G > 0$ ✓ **Minimum Temperature** whole number required ($T = \frac{\Delta H}{\Delta S} = \frac{491000}{543}$) = 904 **OR** 905 K ✓	3	**ALLOW 3 SF** up to calculator value **IGNORE** units **ALLOW ECF** for any <u>positive value</u> determined in M1 **Alternative approach for first two marks** ---------- ***ΔH and TΔS at 100°C*** $T\Delta S$ = 373 × 0.543 = 202.539 **Feasibility statement** ($\Delta H > T\Delta S$) 491 > 202.539 **OR** 491000 > 202539 so not feasible

Question			Answer	Mark	Guidance
					Alternative approach for first two marks ---------- ***ΔS_{total} at 100°C*** $\Delta S_{total} = \Delta S_{surroundings} + \Delta S_{system}$ $= \frac{-\Delta H}{T} + \Delta S_{system}$ $= \frac{-491}{373} + 0.543$ $= -0.773(3538874)$ **Feasibility statement** Not feasible when $\Delta S_{total} < 0$
	(c)	**(i)**	Equal number of (gaseous) reactant and product molecules/moles **OR** (pressure) units cancel ✓	1	**ALLOW** equal number of terms in numerator and denominator **ALLOW** units cancelling as shown in an equation **DO NOT ALLOW** references to concentration **IGNORE** same number of reactants and products (need moles/molecules)

Question			Answer	Mark	Guidance
		(ii)	**FIRST CHECK ANSWERS ON THE ANSWER LINES** **IF answer = 74(kPa) <u>for both</u> award 3 marks** ---------- $p(H_2O)\ p(CO) = \frac{p(H_2) \times p(CO_2)}{K_p}$ $= \frac{211 \times 211}{8.13}$ = 5476.(137761) ✓ (At equilibrium) $p(H_2O) = p(CO)$ / the same value on both partial pressure answer lines ✓ $p(H_2O)$ **AND** $p(CO)$ =√ 5476.(137761) = 74(.0) (kPa) ✓	3	**ALLOW ECF** from incorrect x^2 **ALLOW** $p(H_2O) = p(CO) = x$ So $x^2 = \frac{p(H_2) \times p(CO_2)}{K_p}$ = 5476.138 scores first 2 marks
		(iii)	Lower temperature **AND** (forward reaction) is exothermic / reverse reaction is endothermic ✓ K_p (has increased and) equilibrium position shifted to the right ✓	2	**ALLOW ORA** **ALLOW** shifts to the products/increases yield or **AW** **ALLOW** value of $p(H_2O)\ p(CO)$ decreased / $p(H_2)\ p(CO_2)$ increased

Question			Answer	Mark	Guidance
18	(a)	(i)	(Pt has) different state / phase (to reactants) ✓	1	**ALLOW** Pt is a solid but reactants are gases **IGNORE** products
18		(ii)	Correct drawing of a Boltzmann distribution curve must start within the first small square nearest to the origin **AND** must not touch the x-axis at high energy **AND** not be horizontal for more than 1 large square ✓ Catalyst (provides a reaction pathway with) lower activation energy **OR** E_a to the right of $E_{c/cat}$ marked on graph **AND** A greater proportion / more of molecules / particles have energy greater or equal to the activation energy / $E \geq E_a$ ✓	2	**DO NOT ALLOW** multiple curves **IGNORE** a slight inflexion at the end of the curve less than one <u>small</u> square **ALLOW** shading on the graph if linked to the idea of more molecules **ALLOW** more molecules have (sufficient) energy to react for $E \geq E_a$ **IGNORE** more (frequent) successful collisions **BUT** **DO NOT ALLOW** more frequent collisions **IGNORE** more molecules have / meet / reach activation energy **DO NOT ALLOW** molecules have more energy (confusion with temperature)
		(iii)	Lower temperature can be used (for the same yield) **OR** less energy demand / required to heat reaction **OR** less fossil fuels need to be burnt **OR** reduction in CO_2 **OR** catalyst can be reused ✓	1	

Question			Answer	Mark	Guidance
18	(b)		(Experiments 1 & 2) As $[O_2]$ × 2, rate × 2 **AND** 1st order with respect to O_2 ✓ (Experiments 1 & 3) As [NO] × 1.5, rate × 2.25 **AND** 2nd order with respect to NO **OR** (Experiments 2 & 3) As [NO] × 1.5 and $[O_2]$ ÷ 2, rate × 1.13 ($1.13 = 1.5^2 \div 2$) **AND** 2nd order with respect to NO ✓ rate = $k\,[NO]^2\,[O_2]$ ✓ $k = \frac{7.45 \times 10^{-4}}{0.04^2 \times 0.035} = 13(.30357...$ **OR** $k = \frac{1.49 \times 10^{-3}}{0.04^2 \times 0.070} = 13(.30357...$ **OR** $k = \frac{1.68 \times 10^{-3}}{0.06^2 \times 0.035} = 13(.33333...$ ✓ Units: $dm^6\ mol^{-2}\ s^{-1}$ ✓	5	**ALLOW ORA** throughout Check table for working if none shown **ALLOW 2 SF** up to calculator value **ALLOW ECF** from incorrect orders **ALLOW** in any order **ALLOW ECF** from incorrect rate equation e.g. 1st order wrt NO units $mol^{-1}\ dm^3\ s^{-1}$ zero order wrt NO units: s^{-1}

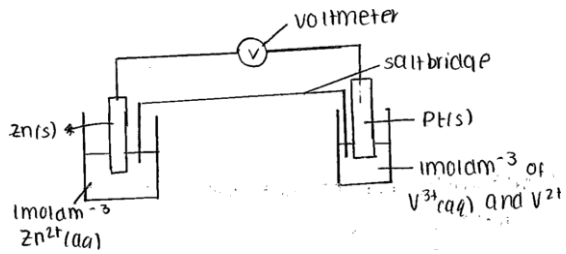
Question			Answer	Mark	Guidance
18	(c)	(i)	11.4 / 11.35 ✓	1	
		(ii)	Straight line of best fit ✓  **Gradient** Gradient from a straight line in range of (–)28300 to (–)31300 ✓ **CHECK THE ANSWER ON ANSWER LINE** **If answer = 240 to 260 (kJ mol^{-1}) award last two marks** ---------- ***E*$_a$ calculation** *E*a = (–) gradient × *R* (8.314) ✓ *e.g. from –30000, E_a = (+)249420 (J mol^{-1})* *E*a to **2 SF** and in kJ mol^{-1} ✓ *e.g. 250(kJ mol^{-1})*	4	***FULL ANNOTATIONS MUST BE USED*** Mark first two marking points independently **ALLOW** rounding to 2SF Best fit line judged from their points using the following guidance: Line should go through ranges: Top left 15.3 – 15.7 Bottom right 6.3 – 6.8 and **exclude** anomalous point at ln(*k*) = 11.4 Consider using ruler tool on RM ***Marks are for intermediate calculations*** **ALLOW ECF** from an incorrect gradient **IGNORE** signs for both E_a calculation and gradient **DO NOT ALLOW** a negative E_a

Question			Answer	Mark	Guidance
19	(a)		0.82 ✓	1	(pH = –log(0.15)) =0.82 **2 DP** required
	(b)	(i)	Higher (pH) **AND** (Nitric acid fully ionises and) nitrous acid partially dissociates/ionises ✓ Lower <u>concentration</u> of H^+ ions (in nitrous acid) ✓	2	**DO NOT ALLOW** nitric acid is a stronger acid (in the question) **IGNORE** easily dissociates **IGNORE** does not fully dissociate/dissociates less **ASSUME** "It" refers to HNO_2
		(ii)	(Simultaneous) oxidation and reduction of (the same) <u>element</u> ✓ N from +3 (in HNO_2) to +5 (in HNO_3) **AND** N from +3 (in HNO_2) to +2 (in NO) ✓ N is oxidised to HNO_3 **AND** N is reduced to NO ✓	3	**ALLOW** N / nitrogen for element **IGNORE** species for element + required **ALLOW** 3+, 5+, and 2+ **DO NOT ALLOW** N^{3+}, N^{5+} and N^{2+} **ALLOW** clearly assigned oxidation numbers above the equation if not quoted on the answer line

Question			Answer	Mark	Guidance
	(c)*		**Level 3 (5–6 marks)** Correct method for the calculation of $[H^+]$ **AND** correct method for the calculation of $[CH_3CH_2COO^-]$ **AND** correct mass of CH_3CH_2COONa **AND** explains how pH changes in a buffer when OH^- is added with reference to an equilibrium equation *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Correct method for the calculation of $[H^+]$ **AND** correct method for the calculation of $[CH_3CH_2COO^-]$ **AND** attempt at a method for calculation of mass of CH_3CH_2COONa **OR** an attempt at an explanation of how pH changes in a buffer when OH^- is added **OR** Correct method for the calculation $[H^+]$ **AND** attempt of method for calculating $[CH_3CH_2COO^-]$ **AND** correct method for calculation of mass of CH_3CH_2COONa **OR** an attempt at an explanation of how pH changes in a buffer when OH^- is added *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*	6	**ALLOW** use of **2 SF** up to calculator value **ALLOW** use of HA and A^- **<u>Calculation of concentrations</u>** $[H^+] = 10^{-pH} = 10^{-4.85}$ $= 1.4(125375\ldots) \times 10^{-5}$ mol dm^{-3} $[CH_3CH_2COO^-] = \frac{K_a \times [CH_3CH_2COOH]}{[H^+]}$ $= \frac{1.32 \times 10^{-5} \times 0.180}{1.4(125) \times 10^{-5}}$ $= 0.168(208)$ mol dm^{-3} **OR** 0.16971**…** mol dm^{-3} if 1.4×10^{-5} used This method could be contained within the working for the mass calculation **<u>Calculation of mass</u>** $n(CH_3CH_2COO^-) = 0.168 \times 0.125$ $= 0.0210(26)$ (mol) $n(CH_3CH_2COONa) = n(CH_3CH_2COO^-)$ $M_r = 96.0$ $m(CH_3CH_2COO^-) = 0.0210(26) \times 96.0$ $= 2.02$ g **OR** 2.018 g **ALLOW** range 2.00 g to 2.04 g **ALLOW** alternative methods that lead to correct mass.

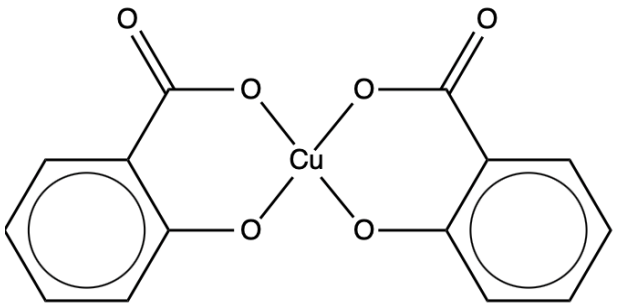
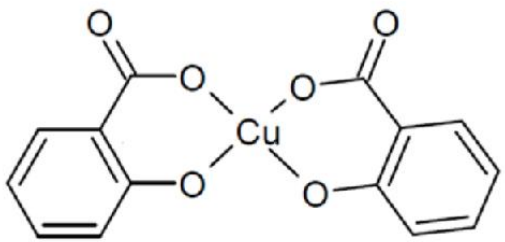
Question			Answer	Mark	Guidance
			Level 1 (1–2 marks) Method for the calculation of $[H^+]$ **AND** $[CH_3CH_2COO^-]$ **OR** correct method for calculation of mass of CH_3CH_2COONa **OR** Explanation of how pH changes in a buffer when OH^- is added **OR** Method for the calculation of $[H^+]$ and a simplistic explanation of how pH changes in a buffer when OH^- is added **OR** Attempts the calculation of concentration and mass with a simplistic explanation *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		**<u>Action of buffer</u>** OH^- from addition of alkali: $H^+ + OH^- \rightarrow H_2O$ **OR** $CH_3CH_2COOH + OH^- \rightarrow CH_3CH_2COO^- + H_2O$ **OR** OH^- reacts with H^+ / CH_3CH_2COOH / (propanoic) acid $CH_3CH_2COOH \rightleftharpoons H^+ + CH_3CH_2COO^-$ **ALLOW** $HA \rightleftharpoons H^+ + A^-$ equilibrium shifts to the right / (acid) further dissociates restoring $[H^+]$ therefore only a small change in $[H^+]$ minimising change in $\frac{[CH_3CH_2COOH]}{[CH_3CH_2COO^-]}$ Examples of the communication statement for all levels being met could typically include: • clear mathematical working and appropriate units for calculated values • use of full chemical formulae in equilibrium rather than HA / A^-

Question			Answer	Mark	Guidance
					---------- **Alternative approach** **Henderson–Hasselbalch (HH)** **ALLOW** use of **2 SF** up to calculator value $pH = pK_a + \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$ **OR** $= pK_a - \log \frac{[CH_3CH_2COOH]}{[CH_3CH_2COO^-]}$ **e.g.** $4.85 = 4.879426069 + \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$ $-0.029426069 = \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$ $\frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]} = 0.934884354$ $n(CH_3CH_2COO^-) = 0.934(884354) \times 0.125 \times 0.18$ $= 0.0210259898$ $m(CH_3CH_2COO^-) = 0.0210259898 \times 96$ $= 2.01849502$ $= 2.02$ g

Question			Answer	Mark	Guidance
20	(a)	(i)	*Circuit*: complete circuit **AND** voltmeter **AND** *labelled* salt bridge linking two half-cells ✓ *Half cells* Pt **AND** V^{2+} **AND** V^{3+} ✓ Zn **AND** Zn^{2+} ✓ *Standard conditions*: 1 mol dm^{-3} seen anywhere in response **AND** 298 K / 25ºC ✓	4	***FULL ANNOTATIONS MUST BE USED*** Electrodes / salt bridge must at least touch the surface **ALLOW** small gaps in circuit wires **ALLOW** half cells drawn either way around  **ALLOW** 1 M **IGNORE** Equimolar for half cell 4 **IGNORE** 1 mol / dm^3 **IGNORE** pressure **DO NOT ALLOW** 1 mol(e) for concentration
		(ii)	(+)0.5(0) V ✓	1	$E^{\ominus}_{cell}$ = –0.26 – (–0.76) = +0.5 **DO NOT ALLOW** –0.5V

Question			Answer	Mark	Guidance
	(b)		**Equations** $Co + 2VO^{2+} + 4H^+ \rightarrow Co^{2+} + 2V^{3+} + \mathbf{2}H_2O$ ✓ $Co + 2V^{3+} \rightarrow Co^{2+} + 2V^{2+}$ ✓ **Comparison of *E* values** (*E* of) Co / system 3 is more negative/less positive than (*E* of) VO^{2+} / system 5 **AND** (*E* of) Co / system 3 is more negative/less positive than (*E* of) V^{3+} / system 4 ✓ **Equilibrium shift related to *E* values (3/5 OR 3/4)** More negative/less positive (Co) / system 3 shifts left **AND** Less negative/more positive VO^{2+} / system 5 shifts right **OR** Less negative/more positive V^{3+} / system 4 shifts right ✓	4	**ALLOW** multiples **ALLOW** ⇌ **ALLOW** CO as Co **IGNORE** state symbols even if wrong **IGNORE** higher / lower electrode potential **IGNORE** use of < / > for *E* comparison **ALLOW** E_{cell} is (+)0.62V for Co / VO^{2+} cell **AND** E_{cell} is (+)0.02V for Co / V^{3+} cell **ALLOW** both half equation**s** with <u>one</u> headed arrow (→) for each half equation in correct direction for systems 3/5 **OR** systems 3/4 e.g. $2H^+ + VO^{2+} + e^- \rightarrow V^{3+} + H_2O$ **AND** $Co \rightarrow Co^{2+} + 2e^-$ **IGNORE** working on the table, treat as rough working

Question			Answer	Mark	Guidance
21	(a)	(i)	Fe ($1s^2$) $2s^22p^63s^23p^63d^64s^2$ ✓ Cu^{2+} ($1s^2$) $2s^22p^63s^23p^63d^9$ ✓	2	**ALLOW** ($1s^2$) $2s^22p^63s^23p^64s^23d^6$ **ALLOW** upper case letter S and P, and subscripts, e.g. $2S_22P_5$ **IGNORE** ($4s^0$) **IGNORE** electron configuration of copper under the line. Treat as working **DO NOT ALLOW** [Ar] as shorthand for ($1s^2$) $2s^22p^63s^23p^6$
		(ii)	Green precipitate ($FeSO_4$) ✓ (Pale) blue precipitate ($CuSO_4$) ✓	2	**ALLOW** 1 mark for both correct colours stated without precipitate mentioned **ALLOW** ppt / solid **DO NOT ALLOW** dark blue for $CuSO_4$
	(b)	(i)	<u>Donates</u> one/an electron pair (to a metal ion) **AND** forms one/a dative (covalent) / coordinate bond (to a metal ion) ✓	1	**ALLOW** lone pair for electron pair

Question			Answer	Mark	Guidance
		(ii)	Fe = $\frac{12.6}{55.8}$: C = $\frac{54.3}{12}$: H = $\frac{4.5}{1}$: N = $\frac{12.6}{14}$: C*l* = $\frac{16.0}{35.5}$ = 0.226 : 4.525 : 4.5 : 0.900 : 0.451 1 : 20 : 20 : 4 : 2 ✓ $FeC_{20}H_{20}N_4Cl_2$ ✓ (pyridine ligands =) Four / 4 ✓ (coordination number =) Six / 6 ✓	4	**ALLOW** other methods **ALLOW** $FeC_{20}H_{20}N_4Cl_2$ **OR** $Fe(C_5H_5N)_4Cl_2$ for ratio **CORRECT** empirical formulae subsumes ratio mark **DO NOT ALLOW** $Fe(C_5H_5N)_4Cl_2$ for $FeC_{20}H_{20}N_4Cl_2$ (not the empirical formulae)
	(c)		Cis isomer  *Cis/trans* ✓	2	**IGNORE** charge and brackets **ALLOW**  **ALLOW** *geometric* **ALLOW** E/Z

Question			Answer	Mark	Guidance
	(d)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 65.4% award 5 marks** ---------- $n(S_2O_3^{2-}) = \frac{31.15 \times 0.0800}{1000} = 2.492 \times 10^{-3}$ ✓ $n(Cu^{2+})$ in 25 cm^3 = 2.492×10^{-3} **OR** $n(I_2) = 1.246 \times 10^{-3}$ ✓ $n(Cu^{2+})$ in 250 cm^3 = 2.492×10^{-2} ✓ Mass $CuSO_4.5H_2O$ in mixture A = $2.492 \times 10^{-2} \times 249.6$ = 6.22(0032) g ✓ $\% = \frac{6.22 \times 100}{9.51}$ = 65.4 % **(3 SF required)** ✓	5	**ALLOW ECF** throughout **ALLOW 3 SF** up to calculated value **IGNORE** rounding errors after **3 SF** **Common Errors** 4 marks 65.2% (use of 249 rather than 249.6) 41.8% (use of 159.6 ($CuSO_4$)) 32.7% (no use of second ratio) 6.54% (no x 10)
		(ii)	Iron(III) / Fe^{3+} reacts with iodide ions (I^-) to form <u>iodine (I_2)</u> **OR** Iron(III) / Fe^{3+} oxidises I^- ✓	1	**ALLOW ORA** **ALLOW** (because) Iron(III) is reduced by /reacts with thiosulfate

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