

2015 specification
first exams in 2017

Practice Exams for A Level OCR Chemistry A

Paper 3

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Teacher's Introduction

This pack contains four Practice Paper 3s for the OCR A Level Chemistry (A) specification (2017). The papers and corresponding mark schemes in this pack are modelled on material provided by the board.

Paper 3 is entitled 'Unified Chemistry' and covers:

- Module 1: Development of Practical Skills in Chemistry
- Module 2: Foundations in Chemistry
- Module 3: Periodic Table and Energy
- Module 4: Core Organic Chemistry
- Module 5: Physical Chemistry and Transition Elements
- Module 6: Organic Chemistry and Analysis

This paper is designed so it can be used as either a mock examination or a revision tool designed with both students and teachers in mind, allowing students to mark their own progress. Consequently, the mark scheme resembles that produced by OCR in their

Each practice paper contains both short and longer questions in proportion to the sample assessment material. This includes factual recall, explanation and discussion questions, with two 6-mark 'Level of Response' questions per paper, indicated with an asterisk (*).

Papers have been designed to ensure that the 'Mathematical Skills' and 'Practical Activity Groups' (PAGs) specified in the new syllabus are assessed, as well as 'How Science Works' aspects of the syllabus.

Across the three practice paper packs (Papers 1, 2 and 3), coverage of the specific specification analysis grid is also included, enabling teachers to identify questions on exam-technique activities, or as homework assignments.

The author has aimed to include a spread of material from the relevant topics in order to obtain an overview of their students' knowledge and understanding for each unit.

I hope you and your students find this pack useful.

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* resulting from minor specification changes, suggestions from teachers and peer reviews, or occasional errors reported by customers

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Mark Distribution across all Papers

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		TOTAL	1A	1B	1C	1D	2A
Atoms, Equations & Formulae		13	8	4		6	4
Reacting Masses & Gases		36	3		6	4	3
Acids, bases & redox	Titration	24		3	7	1	
	Redox	10	1	3	1		
	Structure	31	2	7	2	5	
	Bonding	31	3	3	3	3	1
Periodicity, Group 2 & Group 7	Periodicity	43	5	5	5	15	
Qual Tests		8	1		4	1	
Enthalpy	Enthalpy Calculation	14		1		6	
	Bond Enthalpies	12			1		
	Hess	1	1	5	1	3	
Rates & Eqm	Rates	7	6	2	6	1	
	Le Chatelier	11		4		1	
Basic Concepts		19					6
Alkanes	Properties & Reactions	24					7
	Addition Polymers	13					4
Alcohols & Halogenoalkanes	Alcohols	16					5
	Halogenoalkanes	15					2
Synthesis	Practical Techniques	5					
Analytical Techniques	IR	13					3
	Mass Spec	9					1
Rates & Eqm (quant)	How fast	41	13	11	7	3	
	RDS	13		2	3		
	Arrhenius	13				8	
	Kc	14		3	6		
	Kp	25	6	9	2	5	
	Ka and pH	30	8	6	6	2	
	Buffers	31			6	10	
Energy	Neutralisation & Indicators	9	1	4	1		
	Lattices	12	6		2		
	Born-Haber	25	6	6	4	1	
	Gibbs and Entropy	18	3	1	6	2	
Redox & Electrode Potentials	Redox Titrations	15	6	9			
	Electrode Potential setup	18	4		5		
	Electrode Potential theory	17	4	1	3	2	
	Fuel Cells	13	1			7	
Transition Elements	Complexes	37	7	8	2	9	
	Reactions	20	1	2	6	5	
	Analysis	17		1	5		
Aromatics	Theory	21					6
	Reactions	17					9
Carbonyls	Phenol	9					
	Reactions	14					
Carboxylic acids	Tests	1					1
		5					1
Esters & Acyl Chlorides		10					5
Nitrogen Compounds	Amines	22					6
	Acids & Amides	9					2
Chirality		11					2
		12					3
Condensation Polymerisation		12					3
C-C bond formation	Nitriles	11					2
		9					1
Synthesis	Reflux	9					1
	Purification	20					6
	Synthetic Routes	27					3
Analysis	Chromatography	16					2
	Qualitative Tests	12					6
	NMR	29					9
Combined Techniques		16					
MATHS			32	31	35	37	8
PRACTICAL			21	18	15	14	15

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Mark Distribution across Pa

		Paper 3A						Paper 3B					
		Q1	Q2	Q3	Q4	Q5	Q6	Q1	Q2	Q3	Q4	Q5	Q6
Atoms, Equations & Formulae Reacting Masses & Gases Acids, bases & redox Titrations Redox Structure and bonding	Atoms, Equations & Formulae	2	2										
	Reacting Masses & Gases	6	6										
	Titrations	1				1							
	Redox	1											
Structure and bonding	Structure	2	2										
	Bonding	2	2										
Periodicity, Group 2 & Group 7 Qual Tests	Periodicity	2		2								1	
	Group 2												2
	Group 7												
	Qual Tests												
Enthalpy Bond Enthalpies Hess Rates & Eqm Le Chatelier	Enthalpy Calculation	2											
	Bond Enthalpies	2			2								
	Hess	3											
Rates & Eqm Le Chatelier	Rates	3											
	Eqm	4											
	Le Chatelier	4											
Basic Concepts Alkanes Alkenes Properties & Reactions Addition Polymers Alcohol Halogenoalkanes Synthesis Analytical Techniques Mass Spec	Alkanes												
	Alkenes												
	Properties & Reactions												
	Addition Polymers												
Alcohol Halogenoalkanes Synthesis Analytical Techniques Mass Spec	Alcohol												
	Halogenoalkanes												
	Synthesis												
Analytical Techniques IR Mass Spec	Practical Techniques												
	IR												
	Mass Spec												
Rates & Eqm (quant) Arrhenius Kc Kp Ka and pH Buffers Neutralisation & Indicators Lattices Born-Haber Gibbs and Entropy Redox Titrations Electrode Potential setup Electrode Potential theory Fuel Cells Complexes Reactions Analysis	How fast	1											
	RDS	4											
	Arrhenius	4											
	Kc	5			5								5
Ka and pH Buffers Neutralisation & Indicators Lattices Born-Haber Gibbs and Entropy Redox Titrations Electrode Potential setup Electrode Potential theory Fuel Cells Complexes Reactions Analysis	Kp												
	Ka and pH												
	Buffers	8											
	Neutralisation & Indicators												
Energy Lattices Born-Haber Gibbs and Entropy Redox Titrations Electrode Potential setup Electrode Potential theory Fuel Cells Complexes Reactions Analysis	Lattices												
	Born-Haber												
	Gibbs and Entropy												
	Redox Titrations												
Redox & Electrode Potentials Electrode Potential theory Fuel Cells Complexes Reactions Analysis	Electrode Potential setup	6											
	Electrode Potential theory	3											
	Fuel Cells	3											
	Complexes	2											
Transition Elements Reactions Analysis	Reactions	2											
	Analysis	2											
Theory Reactions Phenol Reactions Tests Amines Chirality Amino acids & Amides Nitrides Reflex Purification Synthetic Routes Chromatography Qualitative Tests NMR analysis Combined Techniques	Theory												
	Reactions												
	Phenol												
	Reactions												
Carboxylic acids Esters & Acyl Chlorides Nitrogen Compounds Amino acids & Amides Nitrides Reflex Purification Synthetic Routes Chromatography Qualitative Tests NMR analysis Combined Techniques	Tests												
	Amines												
	Chirality												
Condensation polymers C-C bond formation Synthesis Analysis Qualitative Tests NMR analysis Combined Techniques	Condensation polymers	2											
	C-C bond formation	2											
	Synthesis												
Analysis Qualitative Tests NMR analysis Combined Techniques	Analysis												
	Qualitative Tests												
	NMR analysis												
Combined Techniques	Combined Techniques												
Total	70	10	10	13	19	8	10	70	14	18	16	6	10
Maths	13	4	4	4	5			19	10	5			4
Prac	10	2	6	6	2	0		13	2	6	3	2	

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ZigZag Practice Exams

Supporting A Level OCR

Chemistry A

Unit H432

Practice Paper 3B

Name



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Time allowed

1 hour 30 minutes

Information

- The total number of marks available for this paper is 70. The number of marks available for each question is shown in brackets.
- Answer all questions and show all working.

You will need:

An OCR A Chemistry data sheet

You may use:

- A scientific or graphical calculator
- A pencil for graphs and drawings
- A ruler



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Paper 3B

1. A 0.0200 g piece of magnesium was reacted with 50.00 cm³ of HNO₃ of until all the magnesium dissolved.

a) i) Write an equation for the reaction of magnesium and nitric acid.

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ii) Explain whether the reaction with HNO₃ could be more or less than 1:1 molar ratio than magnesium.
been used instead of magnesium.

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The remaining acid was made up to 250 cm³ with distilled water, and was titrated against 0.150 mol dm⁻³ NaOH. The titration was repeated until concordant results were achieved. The table below shows the results of each titration.

b) i) Complete the table to work out the mean titre to one decimal place.

	Titration 1	Titration 2	Titration 3
Start reading (cm ³)	0.00	22.60	
End reading (cm ³)	22.60	44.95	
Titre (cm ³)			
Mean titre to 1 d.p. (cm ³)			

ii) The burette has a maximum error of ±0.1 cm³. State which of the four experimental results is the most accurate, and calculate the percentage error for that result.

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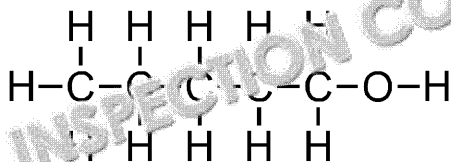
- c) i) Use the mean titre to work out the moles of HNO_3 that remain after the reaction with the magnesium.

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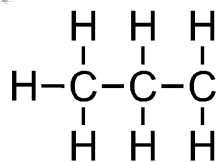
- ii) Use your answer to c (i) to calculate the pH of the nitric acid solution after the reaction with the magnesium.

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2. Compound J and K are related compounds that can both be burnt as fuels.



Compound J



Compound K

- a) Give the IUPAC names for compound J and K

Compound J:

Compound K:

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- b) Describe how compound K can be made from compound J, and give the reaction using molecular formulae.

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- c) Use the bond enthalpy data below to calculate the enthalpy of combustion of compound J.



Bond	Average bond enthalpy / kJ mol ⁻¹
O=O	498
C=O	799
C-O	358
C-H	413
C-C	347
O-H	463

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- d) The values in the table above are calculated in the gaseous state, whereas the experimental values obtained by burning these compounds are in the liquid state. Compare the value you calculated with the experimental value.

- i) Explain whether experimental values are likely to be more or less than the values calculated using the bond enthalpies given in part c).

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- ii) Predict whether the difference between the experimental value using the bond enthalpies in part c) is likely to be greater for c) Justify your prediction.

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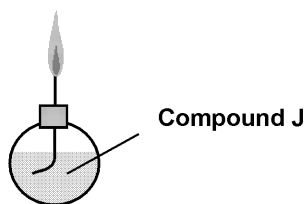
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- e)* Explain, using a diagram to support your answer, how simple laboratory equipment can be used to calculate an accurate experimental value for the enthalpy of combustion of compound J provided in a spirit burner as shown below. You do not need to include a diagram.



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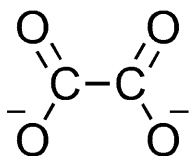
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3. Vanadium is an element that forms a rich variety of aqueous complexes containing both organic and inorganic ligands.

One example is the bidentate oxalate ligand, which may be abbreviated



Oxalate ligand

- a) Write an equation for the formation of $[V(ox)_3]^{3-}$ from a hexaaqua vanadium(III) ion, assuming that the vanadium is neither oxidised nor reduced in the reaction.

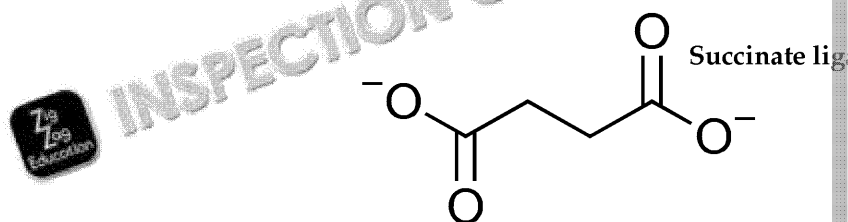
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- b) $[V(ox)_3]^{3-}$ can exist as optical isomers. Draw the structure of these isomers, showing that oxalate binds through the two C–O⁻ oxygens.

- c) A related organic ligand, known in biochemistry as the succinate ligand, is shown below.



Succinate ligand

- i) Give the IUPAC name for this ion.

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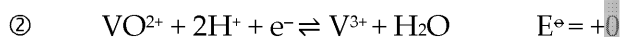
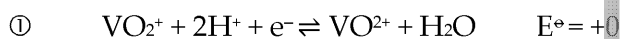


- ii) Suggest the reagents and any relevant conditions needed to form $C_4H_8Br_2$ in three steps, drawing the structure of the intermediate

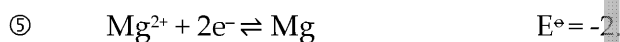


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- d) Conversions between vanadium complexes in different oxidation states are shown in the following electrochemical half cells. Some standard electrode potentials that apply to vanadium half cells are shown.



- i) Explain what vanadium-containing species would be predicted to form when V^{2+} is added to an acidic solution of I_2 and Mg^{2+} separately, with I_2 and with magnesium metal, given the additional data above. Justify your answer.



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- ii) The different oxidation states of vanadium in solution all have a different rate of any reactions that occur between V^{3+} with zinc metal can be determined using colorimetry. Explain why calibration would be needed in order to use colorimetry. Calibration would be carried out.

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4. A chemist found two bottles of unknown salts, P and Q. The chemist performed tests to confirm the identity of the chemicals.

Test 1: Add NaOH and warm gently. Test any vapours with damp red litmus paper.

Test 2: Add $AgNO_{3(aq)}$, followed by dilute NH_3 .

Test 3: Add $BaCl_{2(aq)}$.

	Compound P	
Test 1	Light brown precipitate observed on addition; goes dark brown on warming	No change observed
Test 2	White precipitate; dissolves on addition of ammonia	No change observed
Test 3	No change observed	White precipitate

- a) i) Identify compound P.

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- ii) Give a balanced equation, including state symbols, for the formation of the precipitate in test 2 is carried out on compound P.



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- b) What conclusion can be drawn from the reaction of compound Q with sodium hydroxide solution?

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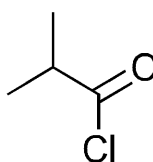
- c) The chemist concluded that test 3 shows that compound Q contains the chemist is wrong to conclude this, and how this test should be confirm the identity of compound Q.

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5. Compound F is an important reagent in synthesis. It can be used in reactions and phenols.



Compound F

- a) Give the structural formula of compound F.
-
- b) i) Draw the product if one molecule of F reacts with one molecule

- ii) Explain one advantage and one disadvantage, in terms of sustainability, of using compound F to make this product rather than using a suitable

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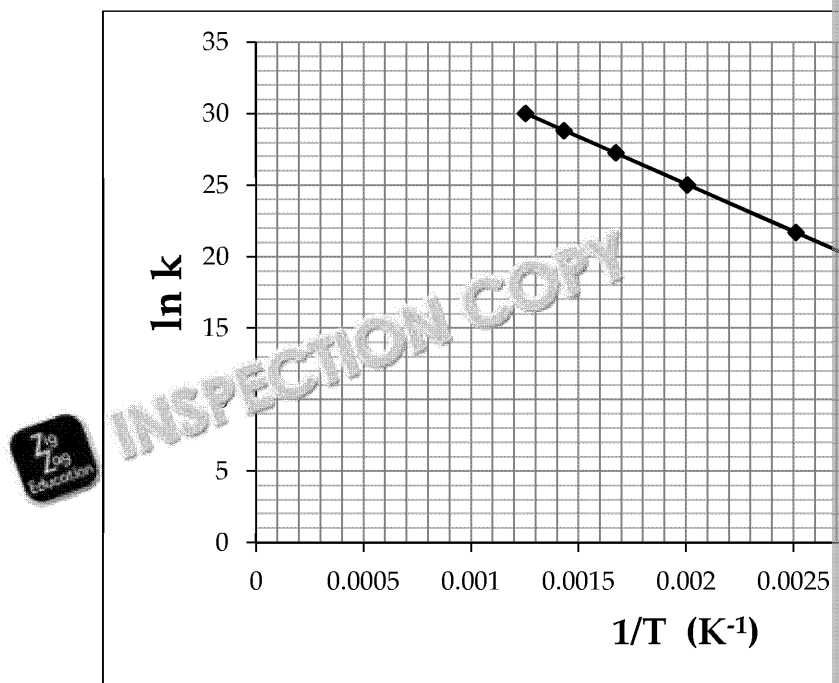
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c) The rate of the reaction of compound F with diethylamine varies with temperature. A graph of $\ln k$ against $1/T$ for this reaction is shown below.

i) Work out the activation energy for this reaction in kJ mol^{-1} , showing your working.



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ii) Calculate the rate, in $\text{mol dm}^{-3} \text{ s}^{-1}$ at 350 K, if the reaction is first order with respect to F and second order with respect to diethylamine. The concentrations of both reactants are $0.0200 \text{ mol dm}^{-3}$ and the rate constant is 0.001 s^{-1} .



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- 6.* Thin-layer chromatography is used extensively in organic chemistry to separate compounds for the purpose of analysis. When used for simple analysis, a solvent is to be used, with the solvent being varied depending on the substances.

The solvent used to carry out the chromatography has to be carefully chosen for compounds in different homologous series or with different functional groups. If the solvent is chosen, all the compounds end up at the top or remain at the bottom.

Outline why different solvents can be used to separate different organic compounds with similar attraction for silica. You should refer to the bonding in specific solvents in your answer.

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ZigZag Practice Exams

Supporting A Level OCR

Chemistry A

Unit H432

Practice Paper 3B

Name



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Time allowed

1 hour 30 minutes

Information

- The total number of marks available for this paper is 70. The number of marks available for each question is shown in brackets.
- Answer all questions and show all working.

You will need:

An OCR A Chemistry data sheet

You may use:

- A scientific or graphical calculator
- A pencil for graphs and drawings
- A ruler



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Paper 3B

1. A 0.0200 g piece of magnesium was reacted with 50.00 cm³ of HNO₃ of until all the magnesium dissolved.

- a) i) Write an equation for the reaction of magnesium and nitric acid.
- ii) Explain whether the reaction with HNO₃ would be more or less likely to be used instead of magnesium.

The remaining acid was diluted to 250 cm³ with distilled water, and was titrated against 0.100 mol dm⁻³ NaOH. The titration was repeated three times. The table below shows the results of each titration.

- b) i) Copy and complete the table to work out the mean titre to one

	Titration 1	Titration 2
Start reading (cm ³)	0.00	22.60
End reading (cm ³)	22.60	44.95
Titre (cm ³)		
Mean titre to 1 d.p. (cm ³)		

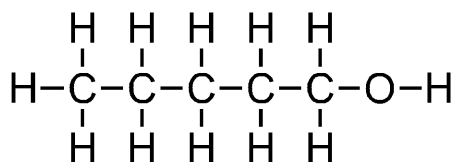
- ii) The burette has divisions of 0.1 cm³. State which of the four expected percentage uncertainty in the titre, and calculate the percentage uncertainty in the experiment.
- c) i) Use the mean titre to work out the moles of HNO₃ that remain after the reaction with the magnesium.
- ii) Use your answer to c (i) to calculate the percentage of the nitric acid that was used in the reaction with the magnesium.

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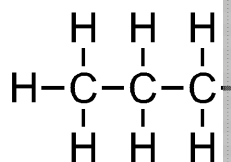
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2. Compound J and K are related compounds that can both be burnt as fuels.



Compound J



Compound K

- a) Give the IUPAC names for compound J and K.
- b) Describe how compound K can be made from compound J, and give the reaction using molecular formulae.
- c) Use the bond enthalpy data below to calculate the enthalpy of combustion of compound K.

Bond	Average bond enthalpy / kJ mol ⁻¹
O=O	498
C=O	799
C-O	358
C-H	413
C-C	347
O-H	463

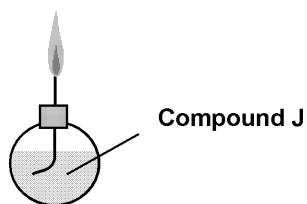
- d) The values in the table above are calculated in the gaseous state, whereas the experimental values obtained by burning these compounds are in the liquid state. Calculate the experimental value for the enthalpy of combustion of compound K from the value you calculated.
- i) Explain whether experimental values are likely to be more or less than the values calculated using the bond enthalpies given in part c).
- ii) Predict whether the difference between the experimental value and the value calculated using the bond enthalpies in part c) is likely to be greater for compound J or compound K. Justify your prediction.

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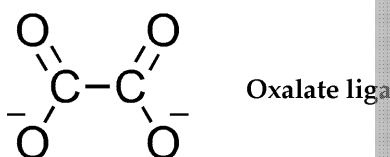


- e)* Explain, using a diagram to support your answer, how simple lab equipment can be used to calculate an accurate experimental value for the enthalpy of combustion of a liquid provided in a spirit burner as shown below. You do not need to include a balanced equation.

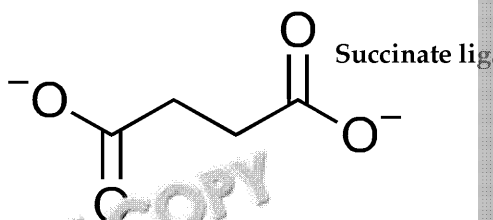


3. Vanadium is an element that forms a rich variety of aqueous complexes containing both organic and inorganic ligands.

One example is the bidentate oxalate ligand, which may be abbreviated as ox.

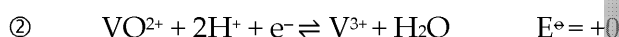
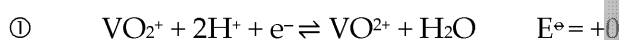


- a) Write an equation for the formation of $[V(ox)_3]^{3-}$ from a hexaaqua vanadium(III) ion, assuming that the vanadium is neither oxidised nor reduced in the reaction.
- b) $[V(ox)_3]^{3-}$ can exist as optical isomers. Draw the structure of these isomers, showing that oxalate binds through the two C–O⁻ oxygens.
- c) A related organic ligand, known in biology as the succinate ligand, is shown below.

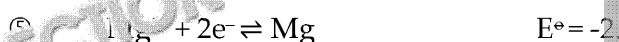


- i) Give the IUPAC name for this ion.
- ii) Suggest the reagents and any relevant conditions needed to form $C_4H_8Br_2$ in three steps, drawing the structure of the intermediate product.

- d) Conversions between vanadium complexes in different oxidation states are shown in the following electrochemical half cells. Some standard electrode potentials that are relevant to vanadium half cells are shown.



- i) Explain what vanadium-containing species would be predicted to form in each of the following reactions, separately, with I_2 and with magnesium metal, given the addition of the relevant half cell above. Justify your answer.



- ii) The standard electrode potentials for the different oxidation states of vanadium in solution all have similar values. Explain why the rate of any reactions that occur between V^{3+} with zinc metal can be determined using colorimetry. Explain why calibration would be needed in order to carry out the colorimetry. Calibration would be carried out.

4. A chemist found two bottles of unknown salts, P and Q. The chemist performed the following tests to confirm the identity of the chemicals.

Test 1: Add NaOH and warm gently. Test any vapours with damp red litmus paper.

Test 2: Add $\text{AgNO}_3(\text{aq})$, followed by dilute NH_3 .

Test 3: Add $\text{BaCl}_2(\text{aq})$.

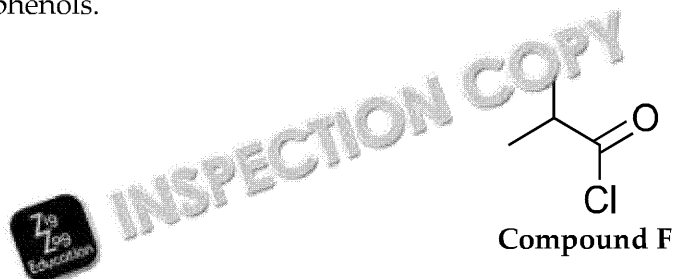
	Compound P	Compound Q
Test 1	Light brown precipitate observed on addition; goes dark brown on warming	No change observed
Test 2	White precipitate; dissolves on addition of ammonia	No change observed
Test 3	No change observed	White precipitate

- a) i) Identify compound P and Q. Justify your answer.
 ii) Write an ionic equation, including state symbols, for the formation of the precipitate observed when test 2 is carried out on compound P.

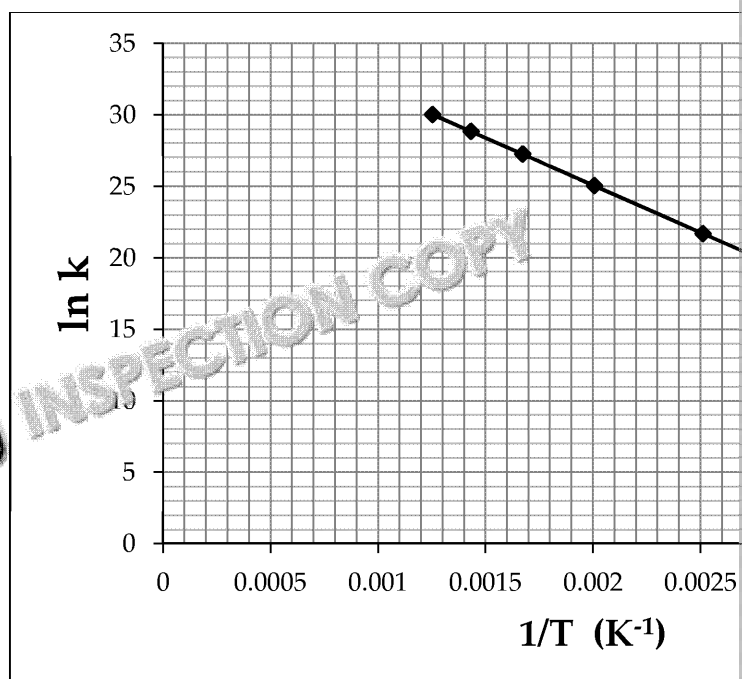
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- b) What conclusion can be drawn from the reaction of compound Q with sodium hydroxide solution?
- c) The chemist concluded that test 3 shows that compound Q contains a carbonyl group. The chemist is wrong to conclude this, and how this test should be used to confirm the identity of compound Q.
5. Compound F is an important reagent in synthesis. It can be used in reactions with alkenes and phenols.



- a) Give the structural formula of compound F.
- b) i) Draw the product if one molecule of F reacts with one molecule of ethene.
ii) Explain one advantage and one disadvantage, in terms of sustainability, of using compound F to make this product rather than using a suitable alkene.
- c) The rate of the reaction of compound F with diethylamine varies with temperature. A graph of $\ln k$ against $1/T$ for this reaction is shown below.
- i) Work out the activation energy for this reaction in kJ mol^{-1} , showing your working.

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- ii) Calculate the rate, in $\text{mol dm}^{-3} \text{ s}^{-1}$ at 350 K, if the reaction is first order in each of the two reactants, and concentrations of $0.0200 \text{ mol dm}^{-3}$ of both are used.

- 6.* Thin-layer chromatography is used extensively in organic chemistry to separate mixtures of compounds for the purpose of analysis. When used for simple analysis, a solvent is chosen to be used, with the solvent being varied depending on the substances to be separated.

The solvent used to carry out the chromatography has to be carefully chosen. For a mixture of compounds in different homologous series, even if different functional groups are present, if a solvent is chosen, all the compounds end up at the top or remain at the bottom.

Outline why different solvents can be used to separate different organic compounds with similar functional groups. You should refer to the bonding in specific functional groups and your answer should include the following:



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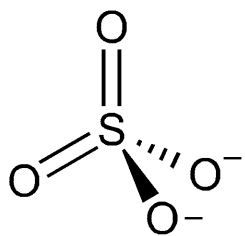
Preview of Questions Ends Here

This is a limited inspection copy. Sample of questions ends here to avoid students previewing questions before they are set. See contents page for details of the rest of the resource.

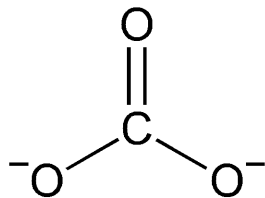
Mark Schemes

Practice Paper 3A

- 1 a) Moles of CO₂ produced in experiment 1 = $\frac{24.58 - 23.75}{44} = 0.01886$
 Moles of YO produced in experiment 1 = 0.01886 ✓
 Ar of Y = $\frac{23.75 - 21.80}{0.01886} - 16 = 87.4$
 Y = Sr ✓
 Moles of water produced in experiment 2 = $\frac{23.42 - 22.40}{18} = 0.05667$
 Moles of ZSO₄ produced = $\frac{0.05667}{6} = 9.444 \times 10^{-3}$
 Ar of Z = $\frac{22.40 - 20.94}{9.444 \times 10^{-3}} - 32.1 - (4 \times 16) = 85.6$ (7.6 from calculator value)
 Z = Ni ✓
- b) Incomplete combustion/oxidation/dehydration of starting material ✓
 Heat loss/constant mass ✓
 OR
 'Spitting' of solid out of crucible ✓
 Use a lid (half on) ✓
 OR
 Starting material includes impurities (which do not decompose) ✓
 Purify the solid before starting ✓
- c)



AND Tetrahedral ✓



AND Trigonal planar ✓

(AWARD 1 mark if both diagrams are correct AND shape names are given)

- d) $2 \text{CH}_3\text{CH}_2\text{COOH} + \text{YO} \rightarrow (\text{CH}_3\text{CH}_2\text{CO})_2\text{Y} + \text{H}_2\text{O}$
 Correct salt formula ✓ (very long else correct ✓)
- 2 a) Chlorine atoms are delocalised electrons in aluminium metal AND ions in solution ✓
 b) The sign of the standard electrode potential shows that reduction of Al³⁺ is more difficult than reduction of H⁺ ✓ (ALLOW AW in terms of gain of electrons, but must be link to sign)
 Therefore, electrons flow from the aluminium electrode to the hydrogen electrode ✓
 The hydrogen electrode is the positive electrode AND the aluminium electrode is the negative electrode ✓

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c)

LEVEL OF RESPONSE QUESTION	
Level 3: (5–6 marks)	Answer is structured in an entirely ordered manner included, and there is an error-free description of the sign of the standard electrode potential.
Level 2: (3–4 marks)	Answer is mostly structured in an ordered manner included, and there is a mostly error-free description of the value of the standard electrode potential.
Level 1: (1–2 marks)	Answer has limited structure. Some key experimental steps and a logical attempt to suggest how to determine the value.
0 marks	No creditworthy response
Indicative Content	
<ul style="list-style-type: none"> • 298K • 1.00 mol dm⁻³ concentrations of solution (ALLOW equal) • 100 kPa pressure of chlorine gas • Use a platinum electrode in a solution of the two Sn ions / chloride ions • Calculate the value on the voltmeter • Subtract (-1.66) from value on voltmeter, then take the negative of this value • This is the standard reduction potential • Over time, the reactants are used up, causing the conditions to be non-standard • Equilibria shift as a result (and the reading on the voltmeter changes) 	

- 3 a) Equation: $\text{H}_2\text{CO}_3 \rightleftharpoons \text{HCO}_3^- + \text{H}^+$ ✓ (ALLOW equation written either way)
 On addition of (small amounts of) H^+ , the position of equilibrium shifts left to decrease the concentration of H^+ / return it to close to its original value ✓
 On addition of (a small amount of) base H^+ ions are used up / removed / the concentration of H^+ decreases
 The position of equilibrium shifts right to regenerate H^+ / increase its concentration / return it to close to its original value ✓
- b) i) Binds to oxygen in the lungs ✓
 Releases oxygen in the muscles / where it is required (for respiration) ✓
- ii) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$ ✓
- iii) ANY TWO OF:
 The same number of protons is holding fewer electrons ✓
 The electrons are drawn closer to the nucleus ✓
 Therefore, more energy is needed to overcome the nuclear/electrostatic attraction ✓
- c) $K_a = 10^{-\text{p}K_a} = 10^{-4.873} = 1.34 \times 10^{-5}$ ✓
 $K_a = \frac{[\text{CH}_3\text{CH}_2\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{CH}_2\text{COOH}]}$ so $[\text{CH}_3\text{CH}_2\text{COO}^-][\text{H}^+] = \frac{[\text{CH}_3\text{CH}_2\text{COO}^-][\text{H}^+]}{K_a}$ ✓
 $[\text{H}^+] = 10^{-\text{pH}} = 10^{-3.75} = 1.78 \times 10^{-4}$ ✓
 $[\text{CH}_3\text{CH}_2\text{COO}^-] = \frac{2.5 \times 10^{-2} \times 10^{-4}}{1.34 \times 10^{-5}}$ ✓ (ALLOW ECF)
 $[\text{CH}_3\text{CH}_2\text{COOH}] = 0.187 \text{ mol dm}^{-3}$ ✓

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- 4 a) Two molecules join to form a larger molecule with the loss of water / a small molecule ✓
 b) Peaks as below. Shifts given as ranges; allow peaks anywhere within this range ✓
 Four peaks ✓
 Shifts correct ✓
 Splitting ✓✓ (AWARD 1 mark for three correct, 2 marks for all four)
 Integrations correct ✓

Shift (ppm)	Splitting	Integration
0.5–1.9	Singlet	9
2.0–3.0	Singlet	2
3.1–4.3	Quartet	2
4.4–5.5	Triplet	3

- c) i) In reflux, the condenser is vertical and is used to condense chemicals back into the flask (for further reaction) ✓

In distillation, the condenser is off the side, and is angled to condense vapour into a separate flask for collection ✓

$$\text{ii) } K_c = \frac{[\text{Ester}]}{[\text{Carboxylic acid}] \times [\text{Alcohol}]} = \frac{[\text{Ester}]}{[\text{Carboxylic acid}]^2}$$

$$\text{so } [\text{Carboxylic acid}] = \sqrt{\frac{[\text{Ester}]}{K_c}} \checkmark$$

$$[\text{Carboxylic acid}] = \sqrt{\frac{0.25}{38}} = 0.08111 \checkmark \text{ (ALLOW 0.0811)}$$

Eqm moles (Carboxylic acid) = Concentration \times Volume

$$\text{Eqm moles (Carboxylic acid)} = \frac{0.08111 \times 200}{1000} = 0.01622 \checkmark$$

$$\text{Start moles (Carboxylic acid)} = 0.01622 + 0.05 = 0.06622 \checkmark$$

$$\text{Start concentration (Carboxylic acid)} = \frac{0.06622}{95} \times 1000 = 0.697 \text{ (mol dm}^{-3}\text{)}$$

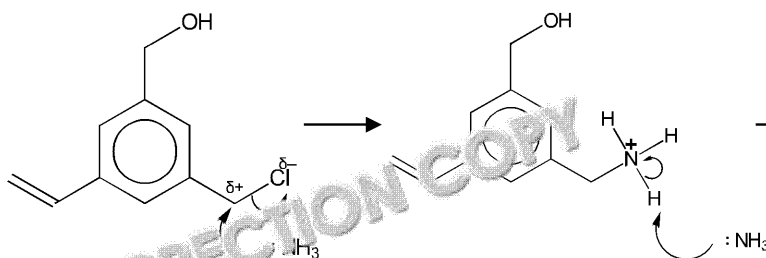
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d)

LEVEL OF RESPONSE QUESTION	
Level 3: (5–6 marks)	Answer is structured in an entirely ordered way. Statements about enthalpy and of the effect of temperature on the value of K_c are comprehensive and correct.
Level 2: (3–4 marks)	Answer is mostly structured in an ordered way. Statements about enthalpy and of the effect of temperature on the value of K_c are correct, but there may be gaps in the answer.
Level 1: (1–2 marks)	Answer has limited structure. Statements about enthalpy and of the effect of temperature on the value of K_c are correct but the statements are not linked together.
0 marks	No creditworthy response.
Indicative Content <ul style="list-style-type: none"> Exothermic means that more energy is released when new bonds are formed than the amount of energy <u>absorbed</u> to break bonds in the reactants. Increasing the temperature causes the position of equilibrium to shift in the direction to oppose the increase in temperature. In the esterification reaction, this means a shift to the left. Concentration of reactants increases and the concentration of products decreases. This increases the value of the denominator and decreases the value of the numerator in the equilibrium expression (ALLOW AW) So the value of K_c decreases. Adding additional reactant initially causes the value of K_c to decrease. The position of equilibrium then shifts in the direction to make more product. In the esterification reaction, this means a shift to the right. Concentration of product increases and concentration of reactants decreases. ... until the concentrations reach a position where the value of K_c is constant. 	

- 5 a) $\text{NO}_2^- + 6\text{e}^- + 8\text{H}^+ \rightarrow \text{NH}_4^+ + 2\text{H}_2\text{O}$ ✓
- b) i) (Light/pale) blue precipitate ✓
- ii) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4 \text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 4 \text{H}_2\text{O}$
 Correct complex formed ✓ Rest of equation correct ✓
- c) i)



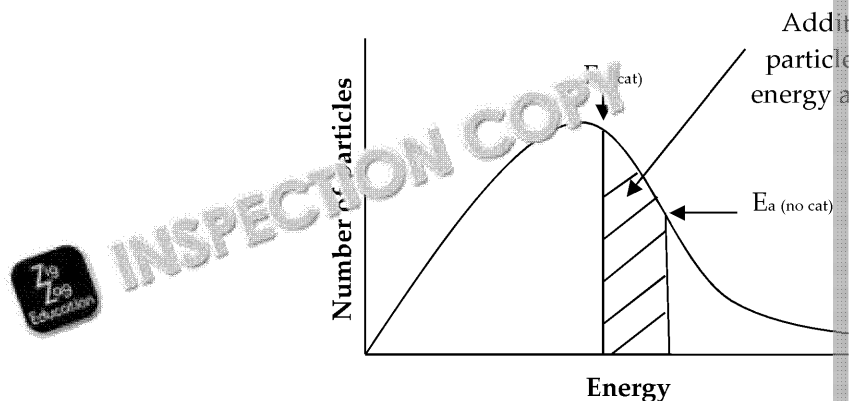
- Correct curly arrow from lone pair on nitrogen to carbon ✓
- Correct curly arrow from bond to chlorine AND correct dipole ✓
- Curly arrows to show removal of hydrogen from intermediate ✓
- ALLOW first 2 marks even if mistakes on rest of structure
- ii) The (nitrogen in the) product still has a lone pair and will, therefore, react with other haloalkane molecules ✓

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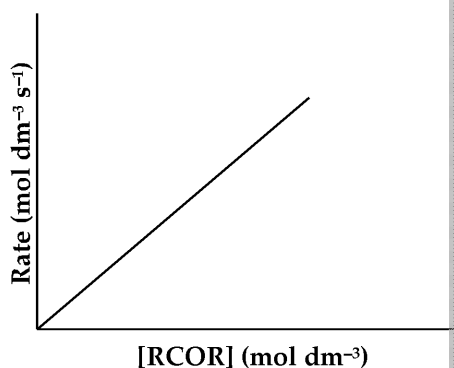
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- 6 a) i) Hydroxynitrile (or cyanohydrin) ✓
 ii) Nucleophilic addition ✓
 b) i) Activation energy is lower in the presence of a catalyst (as it can provide an alternative pathway) ✓
 AND label on graph indicating this (see below) ✓
 Greater proportion of particles with energy above the activation energy (as more particles have enough energy to react) ✓
 More frequent successful collisions ✓



ii)



Straight line with positive gradient ✓

- c) If the rate is multiplied by 8 ($2 \times 2 \times 2$), it indicates that the reaction is first order with respect to the first two species ✓ (IGNORE other interpretations, e.g. second, first and zeroth order). This does not support mechanism 1 since H^+ does not appear in the slowest step and mechanism 2 since H^+ and CN^- and $RCOR$ appear in or before the slowest step. If the rate is multiplied by 4, it indicates the reaction is first order with respect to the second species and zeroth order with respect to the third species.

This supports mechanism 3 AND 4 because only CN^- and $RCOR$ appear in the slowest step. (ALLOW interpretation of 'rate-determining step' and 'slowest step' in the answer) (ALLOW interpretation of 'rate-determining step' and 'slowest step' in the answer that the slowest step is the rate-determining step)

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Preview of Answers Ends Here

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