Oxford Cambridge and RSA

Accredited

AS Level Chemistry B (Salters)
H033/02 Chemistry in depth
Sample Question Paper

Date – Morning/Afternoon
Version 2.0

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry B (Salters)

You may use:
- a scientific or graphical calculator

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **16** pages.

Answer **all** the questions.

1 Some early designed periodic tables attempted to arrange the known elements in a pattern that showed trends in chemical properties.

One version, shown for the first 17 elements in **Fig. 1.1**, was produced by the English chemist John Newlands. This shows the elements thought to exist at the time.

H 1	F 8	Cl 15
Li 2	Na 9	K 16
G 3	Mg 10	Ca 17
Bo 4	Al 11	
C 5	Si 12	
N 6	P 13	
O 7	S 14	

Fig. 1.1

(a) Newlands gave the elements a 'position number' as shown in **Fig. 1.1**.

What do we call 'position number' today?

.... **[1]**

(b) Newland's periodic table and a later version by Mendeleev were arranged by atomic weight (relative atomic mass).
The existence of isotopes was not known and therefore atomic weights were not as accurate as today.
Nickel and cobalt were given the same atomic weight of 59.

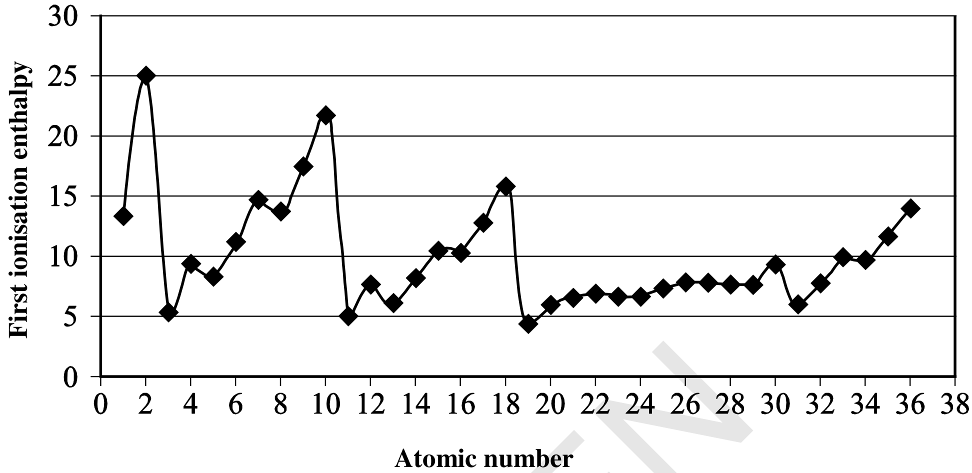
Use the isotopic abundance data below to obtain a value for the atomic weight (relative atomic mass) of nickel to an **appropriate** number of significant figures.

Isotope	^{58}Ni	^{60}Ni	^{61}Ni	^{62}Ni	^{64}Ni
% by mass	68.1	26.2	1.14	3.63	0.930

atomic weight of nickel = ... **[2]**

(c) Another chemist, Lothar Meyer, worked at the same time as Mendeleev. His main contribution was the recognition of *periodic behaviour*, i.e. a repeating pattern of a property shown on a graph.

The graph below shows the repeating pattern of first ionisation enthalpy for elements in the modern periodic table.



(i) Circle **all** the points on the graph above which represent the first ionisation enthalpies of the **Period 2** elements.

[1]

(ii) Ignoring the small drops mid-period, explain why the first ionisation enthalpies broadly increase across Period 2.

....

....

....

....

.... **[3]**

(d) During a flame test, blue light was emitted with a wavelength of 400 nm.

Calculate the molar energy change of this emission.

Include units in your answer.

Energy change .... **[4]**

(e) Magnesium hydroxide is useful as an antacid in some indigestion tablets.

A typical antacid tablet contains 0.292 g of magnesium hydroxide, $Mg(OH)_2$.

A student decides to calculate the volume of stomach acid that the tablet can neutralise. Assume the stomach contains hydrochloric acid of concentration 0.10 mol dm^{-3}.

The equation for the neutralisation reaction is:

$$Mg(OH)_2(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$$

What volume of stomach acid can the tablet neutralise?

volume of acid = ... cm^3 **[2]**

(f) Some students are given a drain cleaner that is described as '50% NaOH solution'. They are told that this means that roughly 50 g NaOH are dissolved in 100 cm^3 solution.

The students have a standard 0.300 mol dm^{-3} solution of HCl and they wish to use this to find the accurate concentration of the drain cleaner.

The students accurately dilute a certain volume of the drain cleaner to 1000 cm^3.

(i) Calculate the volume of drain cleaner the students need to dilute to get a suitable solution for titration with the acid.

volume = ... cm^3 **[3]**

(ii) Suggest the apparatus used by the students to dilute the drain cleaner.

....

.... **[1]**

2 Butene, C_4H_8, is a minor component in crude oil. Butene is used in co-polymerisation with other monomers to form hot melt adhesives.

(a) There are structural isomers of C_4H_8. One of the structural isomers is but-2-ene.

But-2-ene is an isomer of C_4H_8 that exhibits stereoisomerism.

Draw the structures of both stereoisomers of but-2-ene and give their systematic names.

name: ....

name: .... **[2]**

(b) Butane, another four carbon hydrocarbon, is used as fuel in cordless hair straighteners.

(i) Write an equation for the complete combustion of 1 mol of butane.

[1]

(ii) Calculate the volume of oxygen (measured at room temperature and pressure) that would combine with 1.0 g of butane.

volume = ………………………… **[2]**

(iii) 2.15 dm^3 of an unknown hydrocarbon gas had a mass of 5.2 g at 18 °C and a pressure of 101 kPa.

Calculate the relative molecular mass of the gas and suggest what gas it could be.

Name of gas: …………………………………………………… **[3]**

(iv)* Platinum is used as a heterogeneous catalyst in cordless hair straighteners.

Describe a simple model to illustrate how a substance such as platinum can act as a catalyst. Include a definition of the terms *heterogeneous* and *catalyst* in your answer. **[6]**

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Additional answer space if required.

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3 Oxides of nitrogen, NO_x, are important trace species in the atmosphere.

Nitrogen monoxide, NO, is a product of the combustion of fuels.

Nitrogen monoxide is formed by the following reaction at high temperatures in car engines.

$N_2(g) + O_2(g) \rightarrow 2NO(g)$ **Equation 3.1**

(a) The rate of this reaction varies with temperature.

Explain why the rate of a reaction decreases as a result of a decrease in temperature.

....

....

.... **[2]**

(b) Nitrogen monoxide, NO, reacts with oxygen as below.

$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ $\Delta_r H = -114 \text{ kJ mol}^{-1}$ **Equation 3.2**

(i) Describe and explain the effect, if any, of the following changes on the equilibrium concentration of nitrogen monoxide, giving a reason in each case.

- Increasing the pressure at constant temperature.
- Increasing the temperature at constant pressure.

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.... **[4]**

(ii) A mixture of NO and O_2 is left to reach equilibrium.

The equilibrium concentrations of NO and O_2 are shown below.

[NO(g)] / mol dm^{-3}	**[O_2(g)] / mol dm^{-3}**
0.42	1.70

The value of K_c is 8.54 dm^3 mol^{-1}.

Calculate the equilibrium concentration of NO_2(g).

equilibrium concentration of NO_2(g) = ………………………… mol dm^{-3}. **[3]**

(iii) Use the expression for K_c to explain how the position of this gaseous equilibrium would change if some of the NO_2 was removed, assuming the overall temperature remained constant.

....

.... **[2]**

(iv) Draw a labelled enthalpy profile for the forward reaction in **Equation 3.2.**

Show the enthalpy change of reaction, $\Delta_r H$, and the activation enthalpy, E_a.

[3]

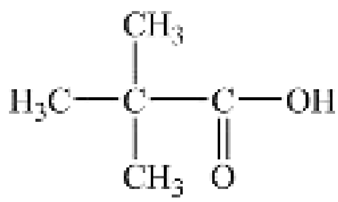
(c) NO reacts with water. One of the products is compound **A**.

Compound **A** contains H: 2.13%; O: 68.1%.

Calculate the empirical formula of compound **A**.

empirical formula = ... **[2]**

4 Pivalic acid, 2,2-dimethylpropanoic acid, is a white solid used in the production of high quality lacquers.

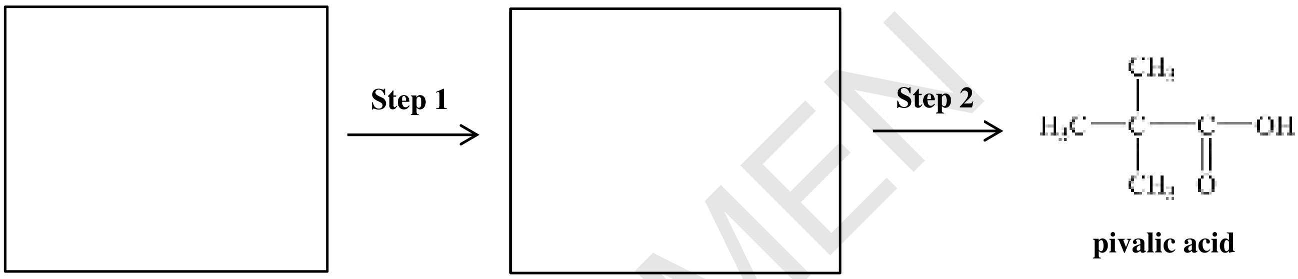


pivalic acid

(a) A student suggests making pivalic acid from 1-bromo-2,2-dimethylpropane in a two-step synthesis.

Write suitable structures in the boxes below to complete the flow diagram.

Give the reagents and conditions for each step.



pivalic acid

1-bromo-2,2-dimethylpropane

Step 1:

reagents and conditions: ....

Step 2:

reagents and conditions: ....

[5]

(b) A student attempted the above synthesis and wanted to test the purity of the pivalic acid that had been made. The student decided to use thin layer chromatography (TLC).

(i) Discuss how appropriate TLC is as a technique for the student's test.

....

....

....

.... **[2]**

(ii) The student tells another student that he will take the TLC plate out of the solvent and examine the spotting pattern.

The other student says he should also stand his dried TLC plate in iodine vapour when chromatography is completed.

Comment on both students' statements.

....

....

.... **[2]**

(iii) A student is asked to prepare 9.45 g of pivalic acid (M_r = 102) starting from 1-bromo-2,2-dimethylpropane (M_r = 150.9).

The student follows an experimental method for this preparation which has a percentage yield of 37.0%.

Calculate the mass of 1-bromo-2,2-dimethylpropane that the student needs to use.

Give your answer to **three** significant figures.

required mass = ... g **[3]**

(iv) Suggest **two** reasons why the percentage yield is relatively low.

....

....

.... **[2]**

(c) The student took the melting point of the pivalic acid that had been prepared.

(i) A student said that if the pivalic acid was impure it would melt over a range of temperatures above the melting point of pure pivalic acid.

Comment on the student's statement.

....

....

.... **[2]**

(ii) What technique should the student have planned to use in the synthesis in order to improve the purity of the product?

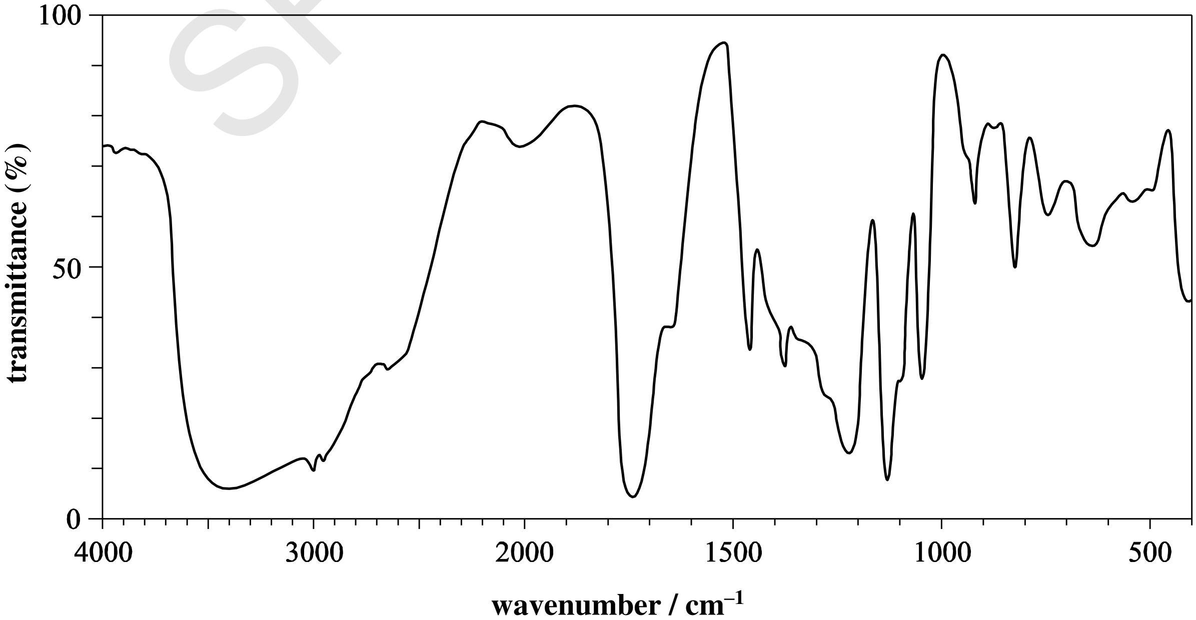
.... **[1]**

(d)* A combination of mass spectrometry and infrared spectroscopy can be used to determine whether pure pivalic acid has been made.

Spectroscopic data for the final product mixture are shown below.

Mass spectrum information for product mixture	
Peak	***m/z* ratio**
Base peak	57
Peak of largest *m/z*	102

IR spectrum of product mixture:



The student claimed that the combination of the mass spectrum information and the IR spectrum show that pure pivalic acid had been made.

Analyse the evidence from the IR spectra (use the *Data Sheet*), the mass spectrum data and the nature of the compounds involved in the synthesis to comment on the validity of the student's claim. **[6]**

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Additional answer space if required.

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END OF QUESTION PAPER

Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

AS Level Chemistry B (Salters)

H033/02 Chemistry in depth

SAMPLE MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 70

This document consists of 16 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris 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 posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

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

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

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 scoris 50% and 100% (traditional 50% 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, email or via the scoris messaging system.

5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

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).

8. The scoris **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 scoris messaging system, or email.

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, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content 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 science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

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 science content determines the level.**
- **The communication statement determines the mark within a level.**

Level of response questions on this paper are **2(b)(iv) and 4(d)**.

11. **Annotations**

Annotation	Meaning
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

12. **Subject-specific Marking Instructions**

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.

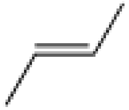
You should ensure that you have copies of these materials.

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.

Question			Answer	Marks	Guidance
1	(a)		Atomic or proton number ✓	1	
	(b)		(68.1 × 58) + (26.2 × 60) + (1.14 × 61) + (3.63 × 62) + (0.930 × 64) /100 = 58.75(664) ✓ = 58.8 ✓	2	**ECF** on 1st mark but **DO NOT ALLOW** sig fig mark unless a followable calculation present
	(c)	(i)	 ✓	1	**ALLOW** individual circles around points
		(ii)	Nuclear charge increases ✓ outer electron(s) in same shell/roughly same distance from nucleus ✓ so attraction (between nucleus and electrons) greater / (electrons) more difficult to remove ✓	3	

Question			Answer	Marks	Guidance
	(d)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** Energy change = 2.99 x10^2 kJ mol^{-1} award 4 marks 400nm x 1 x10^{-9} = 4.00 x10^{-7}m *Recall equations for* $\nu = c/\lambda$ and $\Delta E = h\nu$ = 3.00 x 10^8 m/s / 4.00 x 10^{-7}m = 7.50 x 10^{14} s^{-1} ✓ = 6.63 x 10^{-34} x 7.50 x 10^{14} x 6.02 x 10^{23} ✓ = 299344.5 2.99 x10^2 ✓ kJ mol^{-1} ✓	4	**First mark and second mark can be scored by correctly substituted figures into the expressions**
	(e)		$M(Mg(OH)_2)$ = 58.3 (g mol^{-1}) $n(Mg(OH)_2)$ = 0.292/58.3 = 0.00500 mol ✓ amount of acid reacting = 2 x 0.005 = 0.0100 mol **AND** volume of acid = 0.01/0.1 = 0.100 dm^3 = 100 cm^3 ✓	2	**ALLOW ECF**
	(f)	(i)	[NaOH] = 50 x 10/40 = 12.5 (mol dm^{-3}) ✓ (To create solution of similar concentration to HC*l* solution) dilution needed 12.5/0.3 = 41.67 ✓ (1000/41.67) Volume = 24.0 cm^3 ✓	3	
		(ii)	burette (if 24.0 cm^3 in **(i)**) or pipette (if 25 cm^3 in **(i)**) **AND** (1000 cm^3) volumetric flask	1	**ALLOW ECF** from previous question can use 25.0 cm^3 (pipette) if justified by saying that titre does not have to be exactly 1 : 1
			Total	**17**	

Question			Answer	Marks	Guidance
2	(a)		 *(E)*-but-2-ene  *(Z)*-but-2-ene Correct structures ✓ Correct names ✓	2	**ALLOW** without brackets around *E* and *Z*
	(b)	(i)	$C_4H_{10} + 6.5O_2 \rightarrow 4CO_2 + 5H_2O$ ✓	1	Must be all correct **NOT** multiples (question asks for 1 mol burnt)
		(ii)	$n(C_4H_{10}) = \frac{1.0}{58} = 0.0172$ (mol) ✓ vol. $O_2 = 0.0172 \times 24.0 \times 6.5 = 2.7\ dm^3$ ✓	2	**ALLOW** 2 sig fig up to calculator value Unit required for mark **ALLOW** correct answer given in cm^3
		(iii)	$pV = nRT$ conversion of 101kPa to 101000 and 18^{o}C to 291K **AND** 5.20 x 8.314 x 291 x 1000/101000 x 2.15 ✓ = 57.9357 Mr 58 ✓ Butane gas ✓	3	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td></td><td>(iv)*</td><td>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.

Level 3 (5–6 marks)
Gives a detailed definition of heterogeneous AND catalyst AND clearly describes the detailed steps involved in the catalysis model.

The definitions are fully correct. There is a well-developed description which is clear and logically structured. The steps are relevant and detailed and in a logical order. Candidate demonstrates a clear and confident knowledge of relevant technical language (bonds, phase/state, adsorption).

Level 2 (3–4 marks)
Gives clear definition of catalyst AND heterogeneous AND describes the steps in catalysis model.

The definitions are clear. There is a good description presented with some structure. The steps are in the most-part relevant and have a suitable order. Some indications of a sound grasp of technical language.

Level 1 (1–2 marks)
Defines heterogeneous AND catalyst OR describes the steps in the catalysis model.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

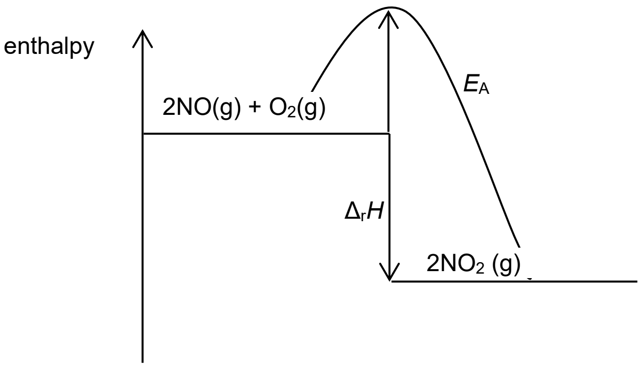
0 marks
No response or no response worthy of credit.</td><td>6</td><td>Indicative scientific points may include:

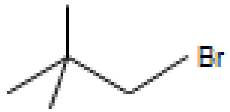
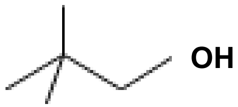
Definitions
• heterogeneous – different phase (state)
• catalyst – speeds up a reaction, unchanged at end
OR provides a route of lower E_A

Steps
• reactants attach to surface
• bonds re-arrange
• products leave.

Detailed steps
• reactants adsorbed onto surface (subsumes 3rd main bullet)
• bonds within reactants weaken and break
• new bonds form (this and above subsume 4th main bullet)
• products diffuse away (subsumes 5th bullet).</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>14</td><td></td></tr>
</table>

Question			Answer	Marks	Guidance
3	(a)		(At lower temperature) fewer molecules/collisions with E_a / activation energy/enthalpy ✓ therefore fewer collisions <u>per unit time</u> (**AW**) result in reaction ✓	2	**NOT** just 'fewer collisions with E_a' for second mark **ALLOW** 'frequency of collisions with necessary E_a decreases'
	(b)	(i)	*Pressure:* (eqm) concentration (of nitrogen monoxide) decreases ✓ Equilibrium shifts to side with fewer molecules (in order to cancel out increased pressure) ✓ *Temperature:* (eqm) concentration (of nitrogen monoxide) increases ✓ Equilibrium moves in endothermic direction ✓	4	
		(ii)	*Expression:* $K_c = \frac{[NO_2]^2}{[NO]^2\,[O_2]}$ ✓ *Calculation:* $[NO]^2 = 8.54 \times 0.42^2 \times 1.70$ ✓ $[NO_2] = \sqrt{8.54 \times 0.42^2 \times 1.70} = 1.6$ (mol dm^{-3}) ✓	3	Award first mark also if this calculation is correct
		(iii)	Value of top line decreases therefore bottom line must decrease to maintain K_c (**AW**) ✓ Eqm position must move to right ✓	2	

Question			Answer	Marks	Guidance
		(iv)	 Energy levels labelled correctly and product line below level of reactants ✓ E_a with single-headed arrow ✓ Difference between energy levels shown marked as Δ_rH ✓	3	**ALLOW** without *y*-axis and/or label **ALLOW** reactants and products without state symbols
	(c)		Calculation of 29.77% N and dividing by A_r values to give H: 2.13; N: 2.13; O: 4.25 ✓ Ratio 1:1:2 **and** HNO_2 ✓	2	
			Total	**16**	

Question			Answer	Marks	Guidance
4	(a)		Step 1  ✓ NaOH **and** warm/reflux ✓ Step 2  ✓ acidified dichromate solution ✓ reflux ✓	5	**ALLOW** any unambiguous structures Reflux optional to warm/heat Reflux essential
	(b)	(i)	TLC will show if <u>any</u> product produced ✓ But not give information on purity ✓	2	
		(ii)	Difficult to see spots as pivalic is white/colourless in solution ✓ Iodine vapour locating agent makes it easier to see spots ✓	2	
		(iii)	Actual n(pivalic acid) $= \frac{9.45}{102} = 0.0926$ (mol) ✓ n(1-bromo-2,2-dimethylpropane) required = $0.0926/37.0 \times 100 = 0.250$ mol ✓ Mass of 1-bromo-2,2-dimethylpropane required $= 0.250 \times 150.9 = 37.7$ (g) **AND** 3 sig figs ✓	3	**ALLOW** 37.8 using unrounded intermediate values but must be to 3 sig figs

Question			Answer	Marks	Guidance
		(iv)	*Any two from:* ✓✓ Loss of material on transferring between vessels Side reactions reducing yield of main product Loss during purification step Reaction had not gone to completion **OR** equilibrium reaction so incomplete	**2**	
	(c)	**(i)**	Range of temperature correct ✓ Always lower than the melting point of the pure substance ✓	**2**	
		(ii)	Recrystallization ✓	**1**	**ALLOW** recrystallize
	(d)*		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Analyses the evidence and uses detailed pieces of evidence from IR spectra **AND** mass spectra to fully support the conclusion that pivalic acid is made. Must state the evidence suggests it is contaminated with alcohol. *The conclusion is well-developed, clear and logically structured. The evidence is relevant and substantiates the student's claim as being partially correct due to the contamination.* **Level 2 (3–4 marks)** Analyses the evidence and uses evidence from IR spectra **AND** Mass spectra, to support the conclusions that pivalic acid has been made. Links evidence to the students claim.	**6**	**Indicative scientific points may include:** **Evidence from mass spectra** • m/z 102 is M_r of pivalic acid • (Base) peak at 57 is fragment ion due to loss of COOH **Evidence from IR spectra** • IR absorption just below 3000 indicates presence of carboxylic OH • absorption at 1700–1725 (allow a number in this range) indicates presence of C=O (in carboxylic acid). **Compounds involved in synthesis** • (But very broad) absorption above 3000 (allow numbers in range 3200–3640) suggests/indicates alcoholic OH. (from step 2 of synthesis)

Question			Answer	Marks	Guidance
			There is a clear conclusion with a line of reasoning and structure. The evidence is in the most-part relevant and supports the student's claim. **Level 1 (1–2 marks)** Analyses the evidence and uses evidence from IR spectra **OR** mass spectra to support the conclusion that an acid is made. Comments whether this agrees or disagrees with the claim. *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.		
			Total	**23**	

Summary of updates

Date	Version	Change
January 2019	2.0	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions