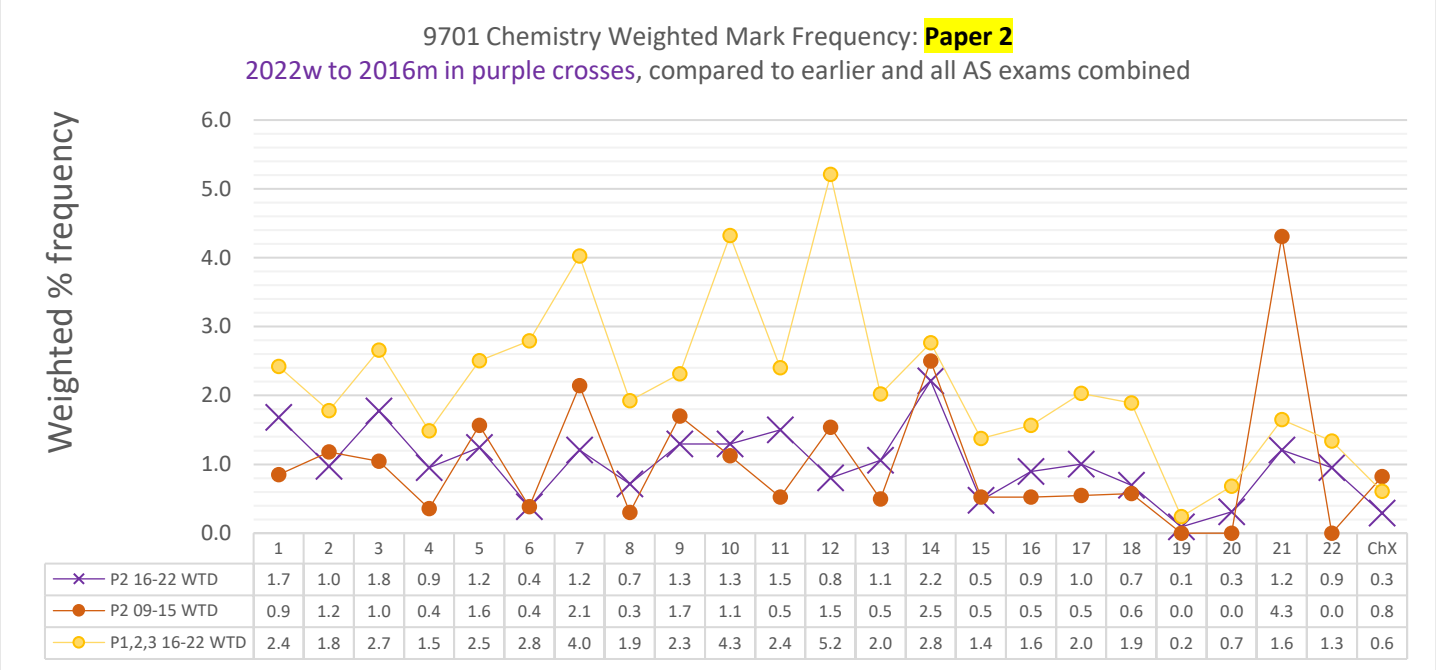
Name: Class: Date:

ALvl Chem 15 EQ P2 22w to 09s Paper 2 Halogen compounds 45marks

As you start and work through this worksheet you can tick off your progress to show yourself how much you have done, and what you need to do next. The first task is just to read the first question and should take you less than one minutes to complete.

Paper 2 Topic 15 Checklist Tick each task off as you go along

	RANK:	P1 Noob	P1 Novice	P1 Bronze	P1 Silver	P1 Gold	P1[1] Winner	P1 Hero	P1 Legend
		1 Q started	1 Q done	10% of marks	25% of marks	40% of marks	50% of marks	75% of marks	100% of marks
Topic (marks)	45		4	5	11	18	23	34	45
Time @75s/mark (minutes)	56		5	6	14	23	28	42	56



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	ChX
P2 16-22 WTD	1.7	1.0	1.8	0.9	1.2	0.4	1.2	0.7	1.3	1.3	1.5	0.8	1.1	2.2	0.5	0.9	1.0	0.7	0.1	0.3	1.2	0.9	0.3
P2 09-15 WTD	0.9	1.2	1.0	0.4	1.6	0.4	2.1	0.3	1.7	1.1	0.5	1.5	0.5	2.5	0.5	0.5	0.5	0.6	0.0	0.0	4.3	0.0	0.8
P1,2,3 16-22 WTD	2.4	1.8	2.7	1.5	2.5	2.8	4.0	1.9	2.3	4.3	2.4	5.2	2.0	2.8	1.4	1.6	2.0	1.9	0.2	0.7	1.6	1.3	0.6

What the most thoughtful students will get out of their extensive studying will be a capacity to do meaningful brain-based work even under stressful conditions, which is a part of the self-mastery skillset that will continue to deliver value for the whole of their lives. Outstanding grades will also happen, but the most important goal from skillful action in study is being better at any important task, even if circumstances do not feel ideal.

As you are moving through your studies you can learn more about yourself by trying out new ways to manage yourself, and analysing how effective those new techniques were. In this reflective process not only will you get better at working positively and productively to deliver ambitious and successful outcomes, but you will be working towards one aspect of life's highest pursuit, summarised and inscribed on the Temple of Apollo at Delphi: "know thyself".

1. To complete these questions, as important as your answer, is checking your answer against the mark scheme.
2. For each page or group of 10-20 marks, convert your mark score into a percentage. This will allow you to see (and feel) your progress as you get more experience and understanding with each topic.
3. Multiple choice questions, done carefully where you explain and show yourself your thinking using written notes as you move through each question, can be more useful than just Paper 2 for students aiming for a C or B grade. Paper 2 should be the larger focus for students aiming for A and A* grades, however.
4. If you find you get a higher percentage answering short answer questions than multiple choice questions that often means you are NOT using the marking scheme correctly; your correct answer might not be fully complete for all the marks you are awarding. The marks easiest to miss rely on providing the largest amount of detail.

[1] **DO NOT** work on these higher levels of completion in your AS year unless you have also achieved at least a "**Silver**" (25%) in the same topic in **Paper 1**, which tend also to be easier questions, as well as ""**Silver**" (25%) in the same topic, if it exists, in Paper 3.

15 Halogen compounds

15.1 Halogenoalkanes

Learning outcomes

Candidates should be able to:

1 recall the reactions (reagents and conditions) by which halogenoalkanes can be produced:
   (a) the free-radical substitution of alkanes by Cl_2 or Br_2 in the presence of ultraviolet light, as exemplified by the reactions of ethane
   (b) electrophilic addition of an alkene with a halogen, X_2, or hydrogen halide, HX(g), at room temperature
   (c) substitution of an alcohol, e.g. by reaction with HX or KBr with H_2SO_4 or H_3PO_4; or with PCl_3 and heat; or with PCl_5; or with $SOCl_2$

2 classify halogenoalkanes into primary, secondary and tertiary

3 describe the following nucleophilic substitution reactions:
   (a) the reaction with NaOH(aq) and heat to produce an alcohol
   (b) the reaction with KCN in ethanol and heat to produce a nitrile
   (c) the reaction with NH_3 in ethanol heated under pressure to produce an amine
   (d) the reaction with aqueous silver nitrate in ethanol as a method of identifying the halogen present as exemplified by bromoethane

15.1 Halogenoalkanes (continued)

4 describe the elimination reaction with NaOH in ethanol and heat to produce an alkene as exemplified by bromoethane

5 describe the S_N1 and S_N2 mechanisms of nucleophilic substitution in halogenoalkanes including the inductive effects of alkyl groups

6 recall that primary halogenoalkanes tend to react via the S_N2 mechanism; tertiary halogenoalkanes via the S_N1 mechanism; and secondary halogenoalkanes by a mixture of the two, depending on structure

7 describe and explain the different reactivities of halogenoalkanes (with particular reference to the relative strengths of the C–X bonds as exemplified by the reactions of halogenoalkanes with aqueous silver nitrates)

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3 The hydrogen halides HCl, HBr and HI are all colourless gases at room temperature.

(e) HBr reacts with propene to form two bromoalkanes, $CH_3CH_2CH_2Br$ and $(CH_3)_2CHBr$.

(iii) The reaction of $CH_3CH_2CH_2Br$ and NaOH is different depending on whether water or ethanol is used as a solvent.

Complete Table 3.2 to identify the organic and inorganic products of the reaction of $CH_3CH_2CH_2Br$ and NaOH in each solvent.

Table 3.2

solvent	organic product(s)	inorganic product(s)
water		
ethanol		

[2]

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(e) 2-bromopropane reacts to form propene, hydrogen bromide and water under certain conditions.

(i) Name this type of reaction.

..... [1]

(ii) Describe the reagents and conditions needed to favour this reaction.

reagents .....

conditions .....

[2]

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4 Iodine is used in many inorganic and organic reactions.

(b) Iodoalkanes contain carbon-iodine bonds.

The simplest iodoalkane is CH_3I.

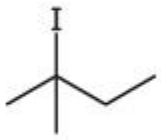
(i) CH_3I can be made from methanol, CH_3OH.

Identify a reagent that can convert CH_3OH to CH_3I.

..... [1]

(c) **J** reacts with NaOH, forming different products dependent on the conditions used.

J

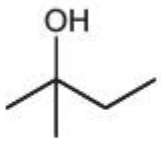


(i) Name **J**.

..... [1]

(ii) **J** reacts with NaOH(aq) to form **K**.

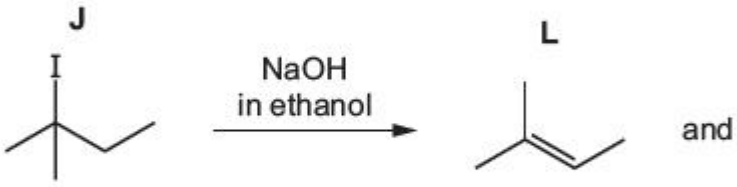
K



Fully name the mechanism of the reaction of **J** with NaOH(aq) to form **K**.

..... [1]

(iii) **J** reacts with NaOH dissolved in ethanol to form a mixture of two alkenes, **L** and **M**. Alkene **L** is shown.



and

M

In the box provided, draw the structure of **M**. [1]

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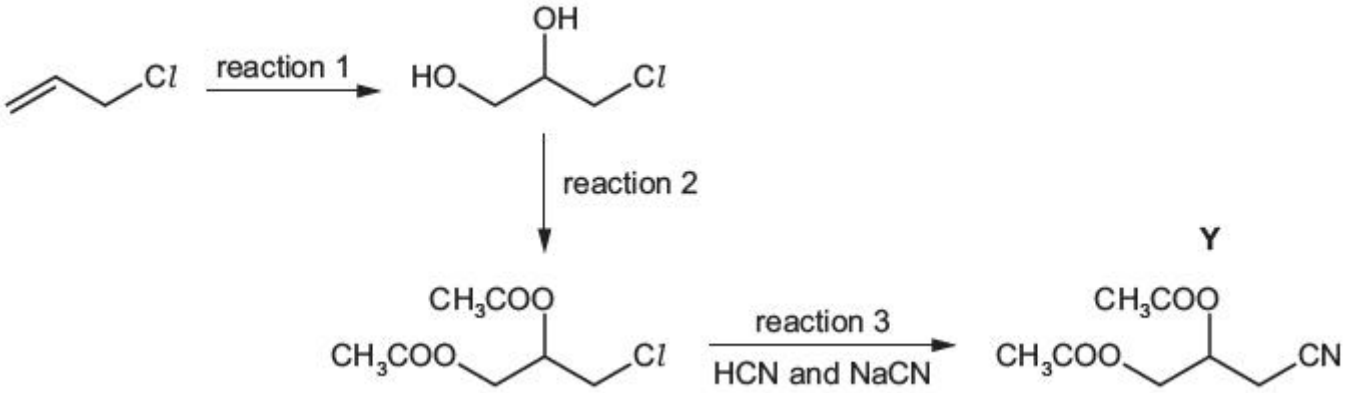

(iii) State the name of the mechanism that occurs in reaction 3.

..... [1]

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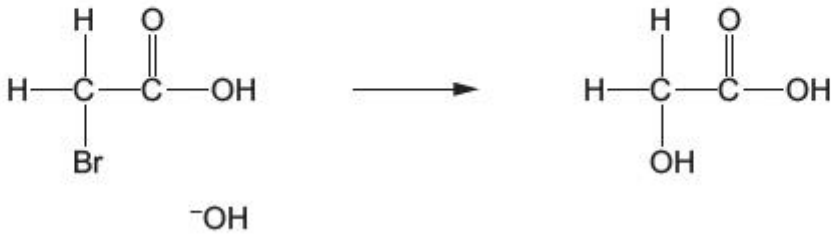
sequence B $CH_3CO_2H \xrightarrow[\text{reaction 3}]{Br_2} CH_2BrCO_2H \xrightarrow[\text{reaction 4}]{} CH_2(OH)CO_2H$

(v) Reaction **4** occurs via an S_N2 mechanism.

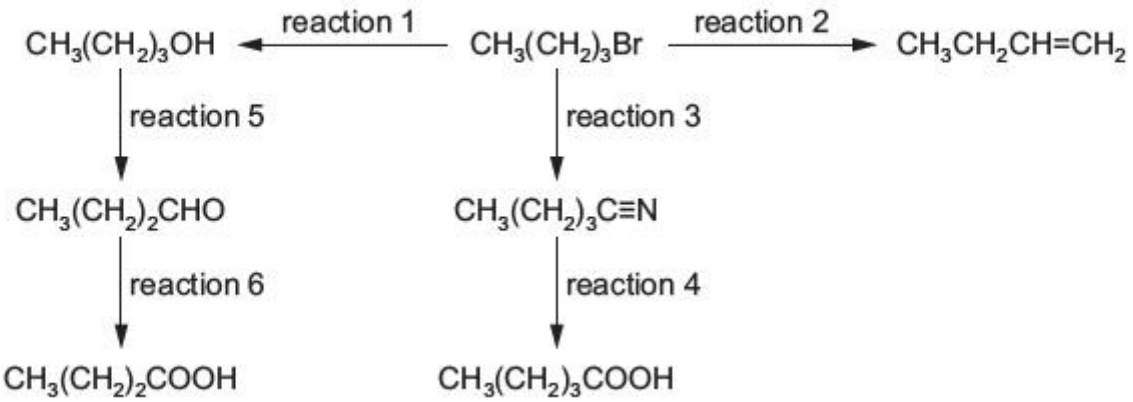
Complete the diagram for the mechanism for reaction **4**.

Include all relevant charges, partial charges, curly arrows and lone pairs.



[2]

3 Some reactions based on 1-bromobutane, $CH_3(CH_2)_3Br$, are shown.



(b) Complete the diagram to show the S_N2 mechanism of reaction 1. R represents the $CH_3(CH_2)_2$ group.
Include all necessary charges, dipoles, lone pairs and curly arrows.

[2]

(c)

(ii) 2-bromo-2-methylpropane is treated with the same reagents as in reaction 1.
Methylpropan-2-ol is formed.

Identify the mechanism for this reaction.
Explain why this reaction proceeds via a different mechanism from that of reaction 1.

mechanism .....

explanation .....

.....

.....

.....

.....

[3]

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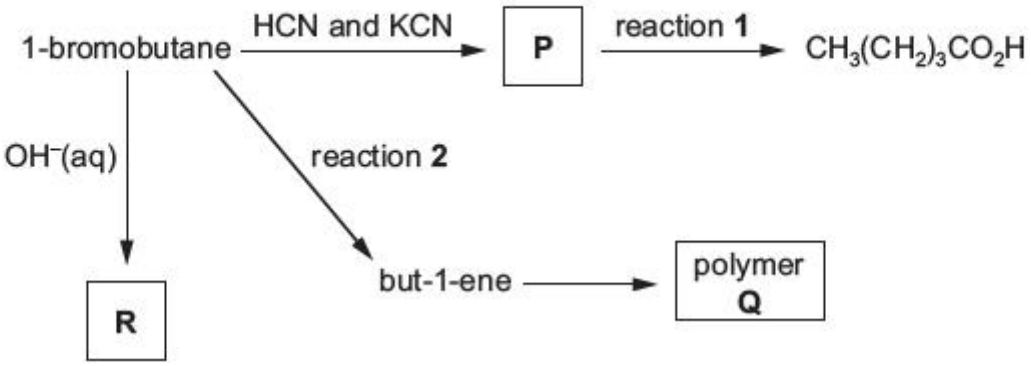
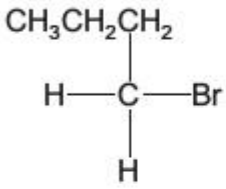
3 **(a)** A series of reactions starting from 1-bromobutane is shown.



(b) Complete the reaction scheme to show the mechanism of the reaction of 1-bromobutane with $OH^-(aq)$ to produce **R**.

Include all necessary charges, dipoles, lone pairs and curly arrows and the structure of **R**.



^-OH

[3]

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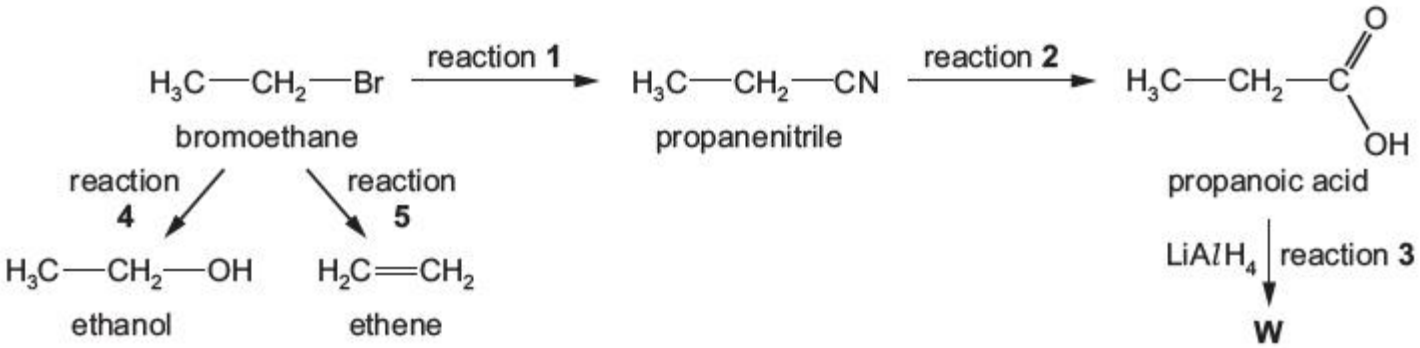
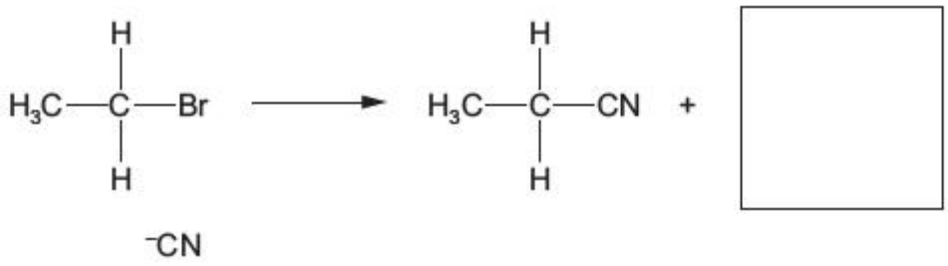
5 A reaction sequence is shown.



(a) Complete the diagram to show the mechanism of reaction **1**. Include all necessary charges, partial charges, lone pairs and curly arrows.



[2]

(c) **(i)** Reactions **4** and **5** use the same reagent.

Give the reagent and conditions needed for reaction **4**.

reagent .....

conditions ..... [2]

(ii) Give the conditions needed for reaction **5**.

..... [1]

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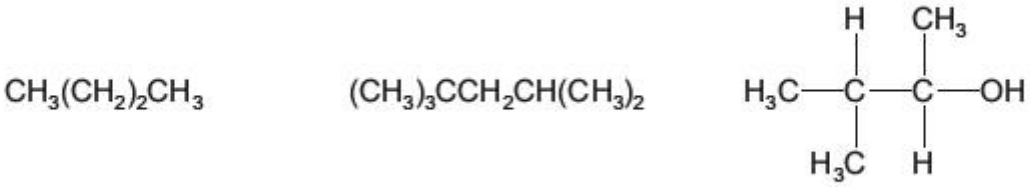
4 The following compounds were all found to be components of a sample of petrol.



G **H** **J**

(e) Compound **J** can be produced from 2-chloro-3-methylbutane, $C_5H_{11}Cl$.

Give the reagent(s) and conditions for this reaction.

..... [1]

[Total: 11]

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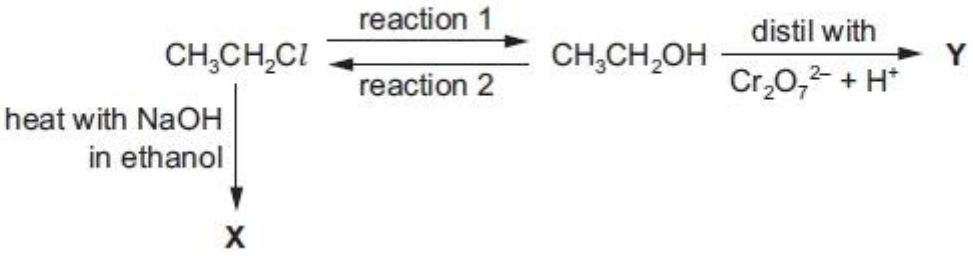
4 Some reactions involving ethanol are shown.



(ii) State the reagent and conditions required for reaction 1.

.....

[2]

(b) (i) Identify the organic product **X**.

.....

[1]

(ii) Nitric acid is added to the products of reaction of CH_3CH_2Cl with NaOH in ethanol. Silver nitrate solution is then added to this mixture.

State what you would observe.

.....

[1]

(iii) Write an ionic equation, including state symbols, for the reaction responsible for the observation in **(ii)**.

.....

[1]

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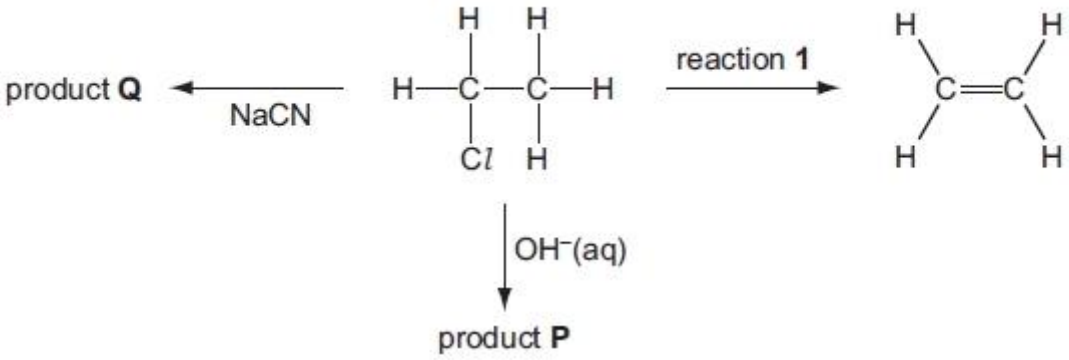
4 Alkanes and alkenes both react with bromine.

(e) Chloroethane undergoes a series of reactions as shown in the diagram below.



(i) Give the reagent and conditions necessary for reaction **1**.

.....

.....

[2]

(ii) Give the **skeletal** formula of product **P**.

[1]

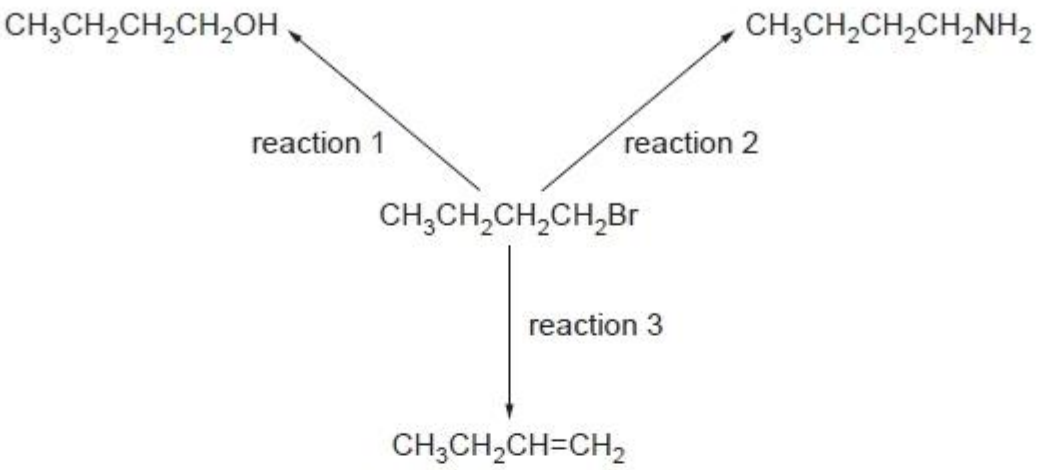
(iii) Give the **displayed** formula and the name of product **Q**.

.....

[2]

4 Halogenoalkanes have many chemical uses, particularly as intermediates in organic reactions.

Three reactions of 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, are shown below.



(a) For **each** reaction, state the reagent and solvent used.

reaction 1 reagent .....

solvent .....

reaction 2 reagent .....

solvent .....

reaction 3 reagent .....

solvent ..... [6]

(b) When 1-iodobutane, $CH_3CH_2CH_2CH_2I$, is reacted under the same conditions as those used in reaction 1, butan-1-ol is formed.

What difference, if any, would there be in the rate of this reaction compared to the reaction of 1-bromobutane?

Use appropriate data from the *Data Booklet* to explain your answer.

.....

.....

.....

..... [3]

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3(e)(iii)	M1: (water solvent)	$CH_3CH_2CH_2OH$ / propan-1-ol	**AND** NaBr / sodium bromide	2
	M2: (ethanol solvent)	CH_3CHCH_2 / propene	**AND** H_2O / water **AND** NaBr / sodium bromide	

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6(e)(i)	elimination	1
6(e)(ii)	**M1** NaOH / KOH	1
	M2 ethanolic solution / ethanol / alcohol + heat	1

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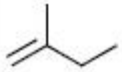
4(b)(i)	HI(g) / PI_3 / P and I_2	1
4(c)(i)	2(-)iodo(-)2(-)methylbutane	1
4(c)(ii)	Nucleophilic substitution / S_N	1
4(c)(iii)		1

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4(c)(iii)	nucleophilic substitution / S_N2	1

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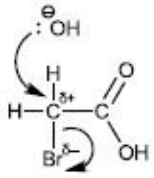
4(b)(v)	 **M1** lone pair on ^-OH **AND** curly arrow from lone pair to C of C—Br **M2** correct dipole on C—Br **AND** curly arrow from bond to Br	2

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3(b)	 M1 lone pair on O of ^-OH AND curly arrow from lone pair to C(—Br) M2 correct dipole on $C^{\delta+}$—$Br^{\delta-}$ AND curly arrow from bond to Br	2
3(c)(ii)	S_N / nucleophilic substitution	1
	$((CH_3)_3CBr$ / tertiary halogenoalkane) forms a stable (carbo)cation / stable intermediate (as charge density on cation is reduced) OR (in) 1-bromobutane / primary halogenoalkane there is no (stable) (carbo)cation / intermediate formed	1
	(because) there are (3 /more) alkyl / methyl groups AND (+) I / (greater) inductive effect OR (because) there is only one / fewer alkyl / methyl group(s) (compared to reaction with 2-bromo-2-methyl propane / tertiary halogenoalkane) AND limited (+) I / (less) inductive effect	1

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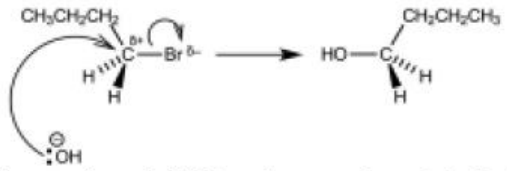
3(b)	 lone pair on O **AND** curly arrow from O to C of C–Br dipole on C–Br **AND** curly arrow from C–Br to Br product (butan-1-ol)	3 1 1 1

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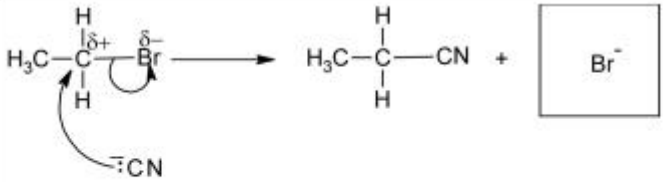
5 (a)	 M1 = lone pair on C of CN− AND curly arrow from lone pair to C of C—Br M2 = correct dipole on C—Br, curly arrow from C—Br bond to Br AND Br^-	[1] [1]	[2]
(c) (i)	sodium/potassium hydroxide aqueous	[1] [1]	[2]
(ii)	ethanol	[1]	[1]

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(e)	NaOH(aq)	[1]	[1]

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(ii)	NaOH / KOH warm / heat / reflux AND aqueous	[1] [1]	[2]
(b) (i)	$CH_2{=}CH_2$ / ethane / C_2H_4 / CH_2CH_2	[1]	[1]
(ii)	White ppt / solid / suspension	[1]	[1]
(iii)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$	[1]	[1]

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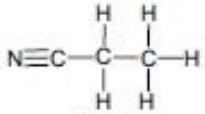
(e) (i)	NaOH/KOH ethanolic / alcoholic **AND** heat / reflux	1 1	2
(ii)		1	1
(iii)	 Propanenitrile / propanonitrile / propionitrile / ethyl cyanide / cyanoethane	1 1	2

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4 (a) reaction 1 reagent NaOH/KOH (1)

solvent H_2O/water/aqueous (1)

reaction 2 reagent NH_3/ammonia (1)

solvent ethanol/C_2H_5OH/alcohol (1)

reaction 3 reagent NaOH/KOH (1)

solvent ethanol/C_2H_5OH/alcohol (1) [6]

(b) with $CH_3CH_2CH_2CH_2I$ rate would be faster (1)

C-I bond is weaker than C-Br bond (1)

C-I bond energy is 240 kJ mol^{-1}, C-Br bond energy is 280 kJ mol^{-1}
data **must** be quoted for this mark (1) [3]