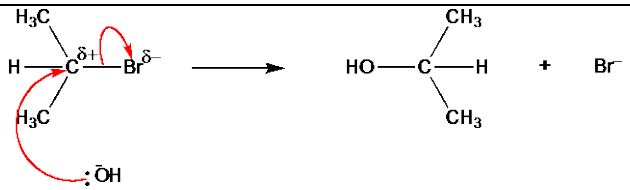
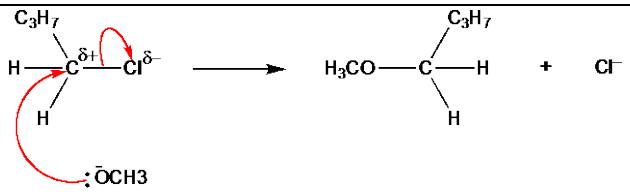
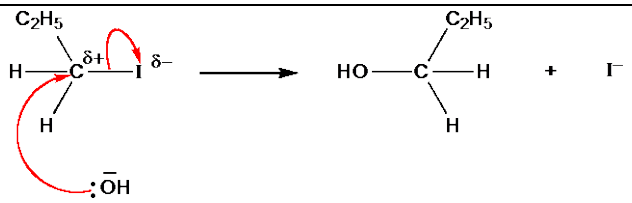
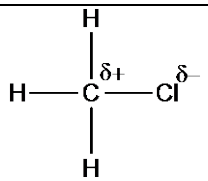
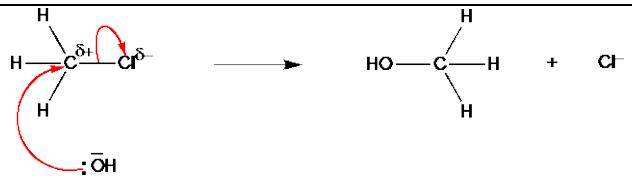
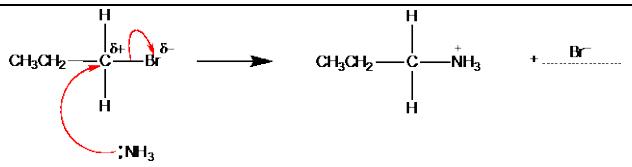
Question number	Answer	Marks	Guidance
1	1-chloropentane 2-bromo-2-methylbutane 1,1-dichloro-3-methylbutane 3,4-dichloro-2,2-dimethylhexane	B1 B1 B1 B1	
2 (a)	An atom or group with an electron pair is exchanged for another atom or group. The atom or group causing the substitution is a nucleophile that donates an electron pair donor.	B1 B1	
2 (b)	$CH_3CHBrCH_3 + OH^- \rightarrow CH_3CH(OH)CH_3 + Br^-$	B1	
2 (c)	 1 mark for dipole shown on the C–Br bond and curly arrow from the C–Br bond to the Br atom 1 mark for curly arrow from lone pair or negative charge on $:OH^-$ to carbon atom in the C–Br bond 1 mark for correct organic product and Br^-	B1 x 3	
2 (d)	The rate would increase because a C–I bond is weaker and broken more easily	B1	
3 (a)	$CH_3CH_2CH_2CH_2Cl + NaOH \rightarrow$ $CH_3CH_2CH_2CH_2OH + NaCl$	B1	
3 (b)	Nucleophilic substitution	B1	
3 (c)	The rate would increase because a C–Br bond is weaker and broken more easily	B1	
3 (d)	 1 mark for dipole shown on the C–Cl bond and curly arrow from the C–Cl bond to the Cl atom 1 mark for curly arrow from lone pair or negative charge on $CH_3O:^-$ to carbon atom in the C–Cl bond 1 mark for correct organic product and Cl^-	B1 x 3	

Question number	Answer	Marks	Guidance
4 (a)	C : H : Br = 37.8/12.0 : 6.30/1.0 : 55.9/35.5 = 3.15 : 6.30 : 1.57 Empirical formula = C_2H_4Cl Molecular formula = $C_2H_4Cl \times 127/63.5$ = $C_2H_4Cl \times 2 = C_4H_8Cl_2$	B1 B1 B1	
4 (b)	**J** = $C_4H_{10}O_2$	B1	
4 (c)	$C_4H_8Cl_2 + 2OH^- \rightarrow C_4H_{10}O_2 + 2Cl^-$	B1	
5	step 1 $NO + O_3 \rightarrow NO_2 + O_2$ step 2 $NO_2 + O \rightarrow NO + O_2$ overall $O_3 + O \rightarrow 2O_2$	B1 B1 B1	
6 (a) (i)	 1 mark for dipole shown on the C–I bond and curly arrow from the C–I bond to the I atom 1 mark for curly arrow from lone pair or negative charge on $:OH^-$ to carbon atom in the C–I bond 1 mark for correct organic product and I^-	B1 x 3	no need to show any lone pairs on oxygen but must have a clear negative sign rather than partial negative charge **IGNORE** lone pairs **IGNORE** products of this reaction **ALLOW** curly arrow from a negative charge or from any part of hydroxide ion If S_N1 mechanism is given then use the mark scheme below correct partial charges on C—I C–I curly arrow from the bond not from carbon atom curly arrow from the OH^- to the **correct** carbocation
6 (a) (ii)	Nucleophilic substitution	B1	
6 (b)	A C–I bond is weaker than a C–Br bond and broken more easily	B1	**ALLOW** ora e.g. C—Br bonds are stronger **OR** broken less easily
7 (a)		B1	
7 (b) (i)	Water	B1	

Question number	Answer	Marks	Guidance
7 (b) (ii)	OH^- ions act as a nucleophile, donating an electron pair.	B1	
7 (b) (iii)	 1 mark for dipole shown on the C–Cl bond and curly arrow from the C–Cl bond to the Cl atom 1 mark for curly arrow from lone pair or negative charge on $:OH^-$ to carbon atom in the C–Cl bond 1 mark for correct organic product and Cl^-	B1 x 3	
7 (b) (iv)	The rate would increase because a C–I bond is weaker and broken more easily	B1	
8 (a) (i)	$CH_3CH_2I + 2NH_3 \rightarrow CH_3CH_2NH_2 + NH_4I$	B1	ALLOW $CH_3CH_2I + NH_3 \rightarrow CH_3CH_2NH_2 + HI$ ALLOW $CH_3CH_2I + NH_3 \rightarrow CH_3CH_2NH_3I$
8 (a) (ii)	 1 mark for dipole shown on the C–Br bond and curly arrow from the C–Br bond to the Br atom 1 mark for curly arrow from $:NH_3$ to carbon atom in the C–Br bond 1 mark for Br^- formed	B1 x 3	Curly arrow **must** start from the lone pair on nitrogen and go to the carbon atom **DO NOT ALLOW** NH_3^- **OR** $^-NH_3$ **ALLOW** δ– on the N atom of NH_3 Curly arrow must start from the bond and go to the Br
8 (b)	**Straight chain comparison of RCl, RBr and RI** Any correct comparison of rate or reaction time between different straight-chain haloalkanes Bond strength/bond enthalpy/bond energy discussed Correct comparison of bond strength/bond enthalpy/energy/bond length **Branched chain comparison of primary, secondary and tertiary RBr** For branching, any correct comparison of rate or	B1 B1 B1 B1	***Examples*** chloroalkane reacts the slowest iodo compound reacts the fastest C–I bond is hydrolysed faster than C–Br C–Br has shorter reaction time than C–Cl **DO NOT ALLOW** references to halogens as elements: *ie* chlorine is less reactive than bromine than iodine

Question number	Answer	Marks	Guidance
	reaction time between bromoalkanes with different amounts of branching A sensible comparison of bond strength OR bond enthalpy/energy/bond length Use of 50 ºC and 60 ºC using information in the table to show that rate increases with temperature At higher temperature, particles have more energy or particles move faster	 B1 B1 B1	**DO NOT ALLOW** chloride, bromide and iodide **ALLOW** this mark if mentioned within effect of halogen, branching **OR** temperature ***Examples*** C–I bond is weaker than C–Br bond C–I bond is the weakest C–Cl bond is shorter than C–I bond C–Cl is strongest bond C–Br is broken more easily than C–Cl Tertiary hydrolyses faster than secondary **OR** reaction time is less with tertiary than primary **OR** secondary hydrolyses faster than primary **OR** branched hydrolyses faster than straight chains **OR** primary hydrolyses the slowest **OR** tertiary hydrolyses the fastest **OR** when halogen on carbon 1 is hydrolysed slower than when halogen is on carbon 2 **DO NOT ALLOW** short chains hydrolyse faster than long chains ***Examples*** C—Hal is weaker in tertiary halogenoalkane **OR** C—Br bond is stronger when it is bonded to carbon 1 rather than carbon 2 **ALLOW** an explanation based on relative stabilities of tertiary, secondary and/or primary carbocations Answer must **quote evidence** from the table to get this mark Rate increases with temperature is **NOT** sufficient **ALLOW** more energy available to break the C–Hal bond

Question number	Answer	Marks	Guidance
			OR more energy vibrates the C–Hal more so bond can break more easily **ALLOW** more successful collisions at higher temperature **ALLOW** more molecules exceed activation energy **ALLOW ORA**