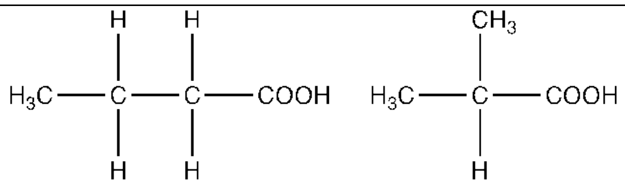
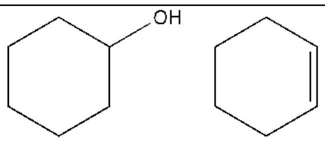
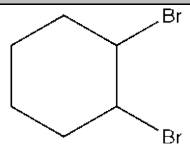
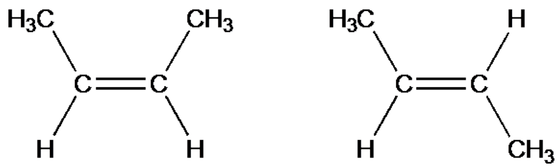
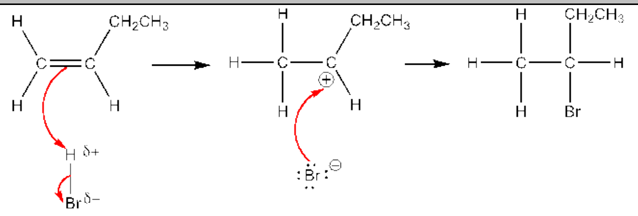
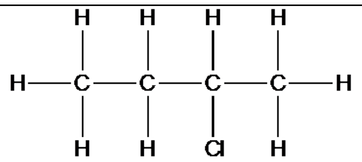
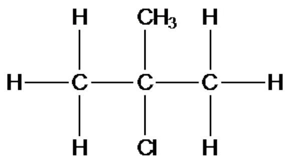
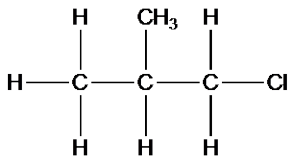
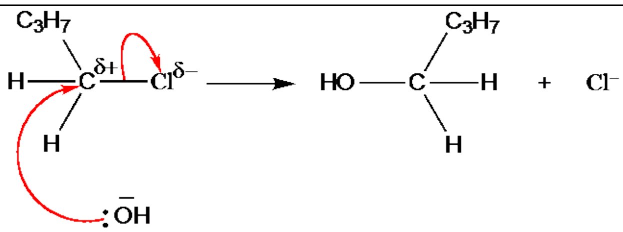
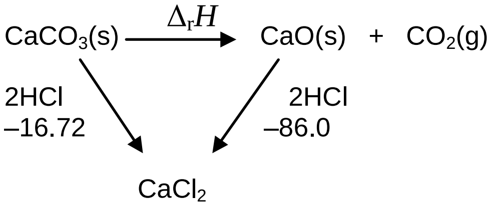
Question number	Answer	Marks	Guidance
1 (a)	Dissolve in water and add to volumetric flask Make up to 250 cm^3 with bottom of meniscus on the graduation line Invert flaks to mix	B1 B1 B1	
1 (b) (i)	*n*(KOH) = 2.95 × 10^{-3} mol *n*(RCOOH) = *n*(KOH) = 2.95 × 10^{-3} mol AND 1 mol RCOOH reacts with 1 mol RCOOH	B1 B1	
1 (b) (ii)	*n*(RCOOH) in 250 cm^3 = 2.95 × 10^{-3} × 250/31.25 = 0.0236 mol *M*(RCOOH) = 2.077/0.0228 = 88.0 g mol^{-1} R = C_3H_7	B1 B1 B1	
1 (d)	 1 mark for each structure	B1 x 2	
2 (a)	 1 mark for each formulae	B1 x 2	
2 (b)	Catalyst	B1	
2 (c)	remove organic layer with a separating funnel dry organic layer with an anhydrous salt (e.g. $MgSO_4$, $CaCl_2$) redistill organic layer	B1 B1 B1	
2 (d)	*n*($C_6H_{12}O$) = 0.170 mol *n*(C_6H_{10}) = 0.0450 mol % yield = 26.5 % Must be to 3 SF	B1 B1 B1	
2 (e)	Add bromine water which is decolourised	B1 B1	

Question number	Answer	Marks	Guidance
			
2 (f)	No O–H peak at 3200–3600 cm^{-1}	B1 B1	
3 (a)	Each successive member differs by CH_2 All members have same functional group	B1 B1	
3 (b)	Boiling point increases with increasing chain length Boiling point decreases with increasing branching Greater surface area of contact gives greater London forces More energy needed to break intermolecular forces with higher boiling point	B1 B1 B1 B1	
3 (c) (i)	Stereoisomers have same structural formulae but different arrangements in space Needs a double C=C bond which does not rotate Also needs two different groups attached to each carbon atom of C=C bond OR But-2-ene has an H atom and CH_3 group attached to each C of C=C OR but-1-ene has two H atoms attached to one C of C=C *E* and *Z* isomers of but-2-ene:  *E* *Z*	B1 B1 B1 B1	
3 (c) (ii)	But-2-ene forms 2-bromobutane only But-1-ene forms 2-bromobutane and 1-bromobutane Secondary carbocation intermediate is more stable AND 2-bromobutane is major product	B1 B1 B1 B1 x 3	

Question number	Answer	Marks	Guidance
	 1 mark for curly arrow from C=C to H or HBr 1 mark for curly arrow from H–Br and correct dipole 1 mark for correct carbocation AND curly arrow from Br^{-} to C^{+} (*For either product*)		
4 (a) (i)	Energy (needed) to remove an electron from each atom in one mole of gaseous atoms	B1 B1 B1	
4 (a) (ii)	Nuclear charge increases Outer electrons are in the same shell. Attraction increases between nucleus and outer electrons	B1 B1 B1	
4 (a) (iii)	In N, there are three unpaired electrons in p orbitals which mutually repel In O, one 2p orbital contains a pair of electrons and the paired electron is lost more easily	B1 B1	
4 (a) (iv)	400 and < 780 (i.e. between values for K and Mg)	B1	
4 (b)	For silicon, covalent bonds are broken on melting For phosphorus, London forces are broken on melting Covalent bonds are much stronger than London forces	B1 B1 B1	
5 (a)	Rate of forward reaction = rate of reverse reaction Concentrations do not change	B1 B1	
5 (b)	Increasing H^{+} shifts equilibrium position to left AND colour turns orange Increasing alkali reacts with H^{+} Equilibrium position shifts to right AND colour turns	B1 B1 B1	

Question number	Answer	Marks	Guidance
	yellow		
5 (c) (i)	Pressure: Equilibrium position shifts to right AND colourless Fewer gaseous molecules on right Temperature: Equilibrium position shifts to left AND brown Forward reaction is exothermic	B1 B1 B1 B1	
5 (c) (ii)	$\Delta_f H$ = (9 + 57)/2 = +33 kJ mol^{-1}	B1	
6 (a)	Nitrogen is reduced **AND** oxygen is oxidised N has changed from +5 to +4 O have changed from –2 to 0	B1 B1 B1	
6 (b) (i)	rate = 240/60 [1] = 40 $cm^3\ s^{-1}$	B1	
6 (b) (ii)	Total volume of gas = 208 cm^3 *n*(gas molecules) = 208/24000 = 8.67 × 10^{-3} mol	B1 B1	
6 (b) (iii)	2 mol $M(NO_3)_2$ produces 5 mol of gas ∴ *n*($M(NO_3)_2$) = 2/5 × 8.67 × 10^{-3} = 3.47 × 10^{-3} mol *M* ($M(NO_3)_2$) = 1.15/3.47 × 10^{-3} = 331.4 g mol^{-1} Molar mass of M = 331.4 – 124 = 207.4 *M* = Pb	B1 B1 B1	
7 (a) (i)	$N_2 + O_2 \rightarrow 2NO$	B1	
7 (a) (ii)	$2NO + O_2 \rightarrow 2NO_2$	B1	
7 (b)	disproportionation is a reaction in which the same element is reduced and oxidised N in NO_2 is reduced from +4 to +3 in HNO_2 N in NO_2 is oxidised from +4 to +5 in HNO_3	B1 B1 B1	
7 (c)	*n*(NO_x) = 150/24000 = 0.00 625 mol number of molecules = 0.00 625 × 6.02 × 10^{23} = 3.76 × 10^{21} mol	B1 B1	
7 (d)	*M*(NO_x) = 0.250/0.00 625 = 40.0 g mol^{-1} *M*(NO_2) = 46 g mol^{-1} and *M*(NO_2) = 32 g mol^{-1} Average is 38 g mol^{-1} so more NO_2 OR 40 is closer	B1 B1 B1	

Question number	Answer	Marks	Guidance
	to 46 so NO_2		
8 (a)	 2-chlorobutane  2-chloro-2-methylpropane  1-chloro-2-methylpropane 1 mark for each structure (name and formula)	B1 x 3	
8 (b) (i)	$CH_3(CH_2)_2CH_2Cl$ **+** $OH^- \rightarrow$ $CH_3(CH_2)_2CH_2Cl$ **+** $OH^- \rightarrow Cl^-$	B1	
8 (b) (ii)	 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	
8 (c)	Oxygen is more electronegative than chlorine OR butan-1-ol is more polar Butan-1-ol has an OH group which forms hydrogen bonds with water	B1 B1 B1	
8 (d) (i)	C_4H_9OH **+** $6O_2 \rightarrow 4CO_2 + 5H_2O$	B1	
8 (d) (ii)	$M(C_4H_9OH) = 74\ g\ mol^{-1}$ $n(C_4H_9OH) = 4.07/74 = 0.055$ mol $n(O_2)$ required $= 5 \times 0.055 = 0.033$ mol volume of $O_2 = 0.033 \times 0.055 = 7.92\ dm^3$ volume of air (21% of air) $= 7.92 \times 100/21 = 37.7\ dm^3$	B1 B1 B1	

Question number	Answer	Marks	Guidance
9 (a)	Rinse with aqueous sodium hydroxide before use	B1	
9 (b)	Mean titre = 20.7 cm^3 $n(NaOH) = 0.106 \times 25.0/1000 = 2.65 \times 10^{-3}$ mol 2 mol NaOH reacts with 1 mol H_2SO_4 $\therefore n(H_2SO_4) = 2.65 \times 10^{-3}/2$ $= 1.325 \times 10^{-3}$ mol concentration $H_2SO_4 = 1.325 \times 10^{-3} \times 1000/20.7$ $= 0.0640$ mol dm^{-3}	B1 B1 B1 B1	
9 (c)	pipette: $0.06/25 \times 100 = 0.24\%$ burette: $(2 \times 0.05)/20.75 \times 100 = 0.48\%$	B1 B1	
10 (a) (i)	**Experiment 1** $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$ **Experiment 2** $CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$	B1 B1	
10 (a) (ii)	$n(CaCO_3) = 2.50/100.1 = 0.0250$ mol 0.0250 mol $CaCO_3$ produces 418 J of energy $\therefore$ 0.0250 mol $CaCO_3$ produces 418/0.0250 = 16 720 J $\therefore \Delta_r H = -16.72$ kJ mol^{-1} $q = mc\Delta T = 51.40 \times 4.18 \times 10.0 = 2150$ J $n(CaO) = 1.40/56.1 = 0.0250$ mol 0.0250 mol CaO produces 2150 kJ of energy $\therefore$ 0.0250 mol CaO produces 2150/0.0250 = 86 000 J $\therefore \Delta_r H = -86.0$ kJ mol^{-1}	B1 B1 B1 B1 B1 B1 B1	
10 (b)	 $\Delta_r H + (-86.0) = -16.72$ $\Delta_r H = -16.72 + 86.0$ $\Delta_r H = +69.28$ kJ mol^{-1}	 B1 B1 B1	

Question number	Answer	Marks	Guidance