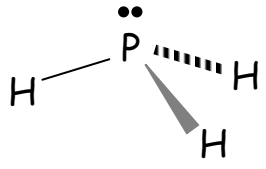
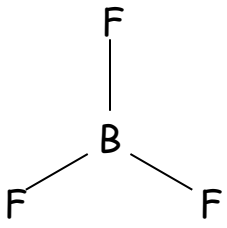
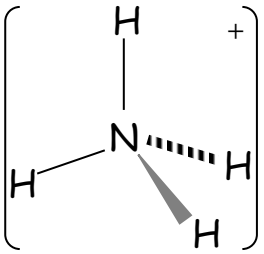
Past Papers Advanced Higher Chemistry

2008 Marking Scheme

Grade Awarded	Mark Required		% candidates achieving grade
	(/125)	%	
A	86+	69%	23.9%
B	71+	57%	25.7%
C	56+	45%	25.8%
D	48+	38%	11.4%
No award	<48	<38%	13.3%

Section:	Multiple Choice	Extended Answer	Investigation
Average Mark:	26.8 /40	28.1 /60	15.3 /25

2008 Adv Higher Chemistry Marking Scheme

MC Qu	Answer	% Pupils Correct	Reasoning
1	D	37	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ = 13 electrons ∴ Aluminium atom Atoms in group 3 form ions with a +3 charge
2	D	69	☒A all electrons are in ground state and are not excited ☒B d-orbitals start in the 3rd shell (i.e. there is no 1d or 2d orbitals) ☒C Electron dropping from 4s to 3s releases energy (of a particular wavelength) ☑D Outer electron in 4s is easier to removed than outer electron in 3s
3	B	74	A: Co^{3+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ — Metals rarely form covalent bonds B:  — trigonal pyramidal C:  — trigonal D:  — tetrahedral
4	C	83	Semiconductor: p-type — Doped With: Group 3 element — Description: Positive hole can migrate across semiconductor Semiconductor: n-type — Doped With: Group 5 element — Description: 5th electron can migrate across semiconductor
5	B	75	☒A NaCl has 6:6 co-ordination as ions have a similar size ☑B CsCl has 8:8 co-ordination as caesium ion is much larger than chloride ion ☒C NaCl has 6:6 co-ordination as ions have a similar size ☒D CsCl has 8:8 co-ordination as caesium ion is much larger than chloride ion
6	A	85	☑A The ionic crystal structure (e.g. 6:6 co-ordination) is dependent in the radii of the ions ☒B The colour of a transition metal ion depends on different d→d transitions ☒C Mn^{2+}, Fe^{2+} and Co^{2+} ions have different atomic numbers so different nuclear charge ☒D Mn^{2+}, Fe^{2+} and Co^{2+} ions have different numbers of d-electrons
7	D	75	☒A sodium hydride in water forms alkali: $NaH + H_2O \rightarrow NaOH + H_2$ ☒B magnesium hydride in water forms alkali: $MgH_2 + 2H_2O \rightarrow Mg(OH)_2 + 2H_2$ ☒C silicon hydride (monosilane) hydrolyses in water: $SiH_4 + H_2O \rightarrow SiO_2 + 4H_2$ ☑D sulphur hydride (H_2S) is a weak acid when dissolved in water: $H_2S \rightarrow H^+ + HS^-$
8	C	58	☒A a base donates a pair of electrons to form a covalent bond ☒B an acid accepts a pair of electrons to form a covalent bond ☑C H^- ion is powerful reducing agent as H^- ions are oxidised themselves ($H^- \rightarrow H + e^-$) ☒D H^- ion is not an oxidising agent as H^- ions are oxidised themselves ($H^- \rightarrow H + e^-$)
9	A	70	Element: X — Oxide: Amphoteric oxide — Reasoning: Elements in Amphoteric oxides are found in the middle of the Periodic Table Element: Y — Oxide: Basic oxide — Reasoning: Elements in basic oxide are metallic and found on left of Periodic Table Element: Z — Oxide: Acidic oxide — Reasoning: Elements in acidic oxide are non-metallic and found on right of Periodic Table
10	C	74	A: MnO_4^- → MnO_4^{2-}, Oxidation Number 7 → 6, Type: Reduction ✓ B: Ag^+ → $[Ag(NH_3)_2]^+$, Oxidation Number 1 → 1, Type: neither ✓ C: $[Fe(CN)_6]^{4-}$ → $[Fe(CN)_6]^{3-}$, Oxidation Number 2 → 3, Type: Oxidation ✓ D: $[Ni(H_2O)_6]^{2+}$ → $[Ni(CN)_4]^{2-}$, Oxidation Number 2 → 2, Type: neither ✓
11	B	53	Species: Ni — Electron Arrangement: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$ — 3d orbital: ↑↓ ↑↓ ↑↓ ↑ ↑ Species: Ni^{2+} — Electron Arrangement: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$ — 3d orbital: ↑↓ ↑↓ ↑↓ ↑ ↑

12	D	43	☒A Positive S^o values indicate an increase in disorder but there is not enough information in the question to determine whether this is the case. ☒B If the equilibrium constant is well above 1 then the reaction must be feasible and the ΔG^o value must be negative for the reaction to be feasible ☒C Catalyst do not alter the value of the equilibrium constant are the concentrations of reactant and products are unchanged ☑D In a system at equilibrium, changing the concentration of a reactant or product does not alter the equilibrium constant
13	D	89	☒A If K=1, then the concentration of reactants and product would be equal (see answer for C) ☒B reactions do not stop at equilibrium (rate of forward reaction = rate of reverse reaction) ☒C The concentrations of reactants and products are constant (not equal) at equilibrium ☑D At equilibrium, rate of forward reaction = rate of reverse reaction
14	C	68	At 630°C: equilibrium constant =3300 at 850°C: equilibrium constant =21 • increase in temperature gives decrease in equilibrium constant (K) • decrease in equilibrium constant (K), achieved by less products at equilibrium • increase in temperature favours the reverse reaction (product yield decreases) ∴ reverse reaction is endothermic and forward reaction is exothermic
15	B	39	**n**o. of mol H^+ = **v**olume x **c**oncentration = 0.5 litres x 0.022 mol l^{-1} = 0.011mol **n**o. of mol OH^- = **v**olume x **c**oncentration = 0.5 litres x 0.020 mol l^{-1} = 0.010mol ∴ **n**o. of mol H^+ left: 0.011 – 0.010 = 0.001mol ∴ $[H^+]$ = 0.001mol = 10^{-3} ∴ $\log_{10}[H^+] = -3$ ∴ $-\log_{10}[H^+] = 3$ ∴ pH=3
16	C	78	☒A bases are proton acceptors not proton donors ☒B bases are proton acceptors not proton donors ☑C bases accept protons to become conjugate acids ☒D bases accept protons to become conjugate acids
17	A	73	☑A this equation breaks the three N-H bonds in ammonia ☒B this equation is the reverse of the enthalpy of formation (doubled) ☒C this equation is the reverse of the enthalpy of formation ☒D this equation represent the enthalpy of combustion of ammonia NH_3
18	A	72	Entropy is a measure of the disorder in a substance. The perfect crystal has zero disorder at 0K (absolute zero temperature)
19	B	85	☒A 2mol of $NO_{2(g)}$ product is more disordered than 1mol of $N_2O_{4(g)}$ reactant ☑B 2mol of $NH_{3(g)}$ product is more ordered than 4mol of $N_{2(g)}/H_{2(g)}$ mixture ☒C $CO_{2(g)}$ makes products much more disordered than $CaCO_{3(s)}$ reactant ☒D 2mol of gas products is much more disordered than 1mol of gas reactants
20	A	74	☑A The volume of reactant is not a condition for standard electrode potentials ☒B Conditions for standard electrode potentials include a temperature of 298K ☒C Conditions for standard electrode potentials include a concentration of 1mol l^{-1} ☒D Conditions for standard electrode potentials include a pressure of 1atmosphere
21	D	70	❶ $X^{2+} + 2e^- \rightarrow X$ $E^o = -0.23V$ ❷ $Ag^+ + e^- \rightarrow Ag$ $E^o = +0.80V$ ❶x-1 $X \rightarrow X^{2+} + 2e^-$ $E^o = +0.23V$ ❷x2 $2Ag^+ + 2e^- \rightarrow 2Ag$ $E^o = +0.80V$ Add ❶'+❷' $X + 2Ag^+ \rightarrow X^{2+} + 2Ag$ $E^o = +1.03V$ Reduction is Gain of Electrons: $2Ag^+ + 2e^- \rightarrow 2Ag$
22	B	78	❶ $Al^{3+} + 3e^- \rightarrow Al$ $E^o = -1.68V$ (old data booklet) ❷ $Cu^{2+} + 2e^- \rightarrow Cu$ $E^o = +0.34V$ ❶x-2 $2Al \rightarrow 2Al^{3+} + 6e^-$ $E^o = +1.68V$ ❷x3 $3Cu^{2+} + 6e^- \rightarrow 3Cu$ $E^o = +0.34V$ Add ❶'+❷' $2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$ $E^o = +2.02V$

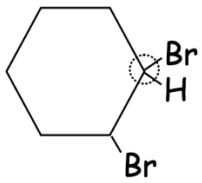
23	A	75	Redox $X + 2Y^+ \rightarrow X^{2+} + 2Y$ Reduction $2e^- + 2Y^+ \rightarrow 2Y$ Oxidation $X \rightarrow X^{2+} + 2e^-$ n=2 as 2mol of electrons are transferred between reduction and oxidation equations $\Delta G^o = -n \times F \times E^o$ $= -2 \times 96500 \times 1.5$ $= -289500 \text{ J mol}^{-1}$ $= -289.5 \text{ kJ mol}^{-1}$
24	A	51	Ethene: nucleophile — Electrons in C=C bond in ethene are attracted to δ+ of Br-Br Br^-: nucleophile — Negative charge of Br^- is attracted to +ve charge of cyclic ion intermediate
25	C	79	☒A volatility and solubility both decrease as chain length increases ☒B volatility decreases as chain length increases ☑C volatility and solubility both decrease as chain length increases ☒D solubility decreases as chain length increases
26	D	70	☒A hydrogen bonding lowers the density of ice compared to liquid water. ☒B hydrogen bonding between ethers and water exists but not in pure ethers ☒C hydrogen bonding of the –OH group in methanol raises it boiling point ☑D neither hydrogen and helium have hydrogen bonding between their particles
27	B	73	☒A acids have two oxygen atoms per molecule ☑B ethers like $CH_3OC_2H_5$ do not react with sodium or lithium aluminium hydride ☒C alkanols react with sodium ☒D aldehyde are reduced by lithium aluminium hydride
28	A	67	☑A alcohols are not acidic ∴ pH=7 ☒B carboxylic acids are acidic ∴ pH<7 ☒C phenol is a weak acid ∴ pH<7 ☒D Benzoic acid (a carboxylic acid) is a weak acid ∴ pH<7
29	C	71	☒A alcohols are less volatile than ethers due to hydrogen bonding in alcohols ☒B alcohols will give a different IR spectra to ethers as alcohols contain O-H bond ☑C both have the formula C_2H_6O and burn to give CO_2 and H_2O ☒D ethanol oxidises to ethanal/ethanoic acid but ethers do not oxidise in this way
30	C	63	☒A substitution of -CN nitrile group adds a carbon ∴ product has 5 carbons ☒B -CN group substitutes onto C_2 of butane so product is not straight chain ☑C -CN group substitutes onto C_2 of butane so 2-methylbutanoic acid is produced ☒D substitution of -CN nitrile group adds a carbon ∴ product has 5 carbons
31	D	48	☒A $2C_2H_5OH + 2Na \rightarrow 2C_2H_5O^-Na^+ + H_2$ ☒B CH_3CHO: alkanals do not react with sodium ☒C $2CH_3COOH + 2Na \rightarrow 2CH_3COO^-Na^+ + H_2$ ☑D $HOCH_2CH_2OH + 2Na \rightarrow Na^+O^-CH_2CH_2O^-Na^+ + H_2$
32	B	63	☒A Ester X made from propanoic acid so name ends in propanoate ☑B Both have formula $C_4H_8O_2$ and X is made from propanoic acid and Y from ethanol ☒C Ester Y has formula $C_4H_8O_2$ but ethyl methanoate has 3 carbons ☒D Ester X made from propanoic acid so name ends in propanoate
33	D	57	☒A Phenol C_6H_5OH is acidic and would not react with hydrochloric acid ☒B Analine $C_6H_5NH_2$ is alkaline and would not react with sodium hydroxide ☒C Benzoic acid C_6H_5COOH is acidic and would not react with hydrochloric acid ☑D $-NH_2$ group would react with acid and the –COOH group would react with alkali
34	D	65	☒A $C_4H_9NH_2$ is a primary amine ∴ hydrogen bonding raises its boiling point ☒B $C_3H_7NHCH_3$ is a secondary amine ∴ hydrogen bonding raises its boiling point ☒C $C_2H_5NHC_2H_5$ is a secondary amine ∴ hydrogen bonding raises its boiling point ☑D $C_2H_5N(CH_3)_2$ is a tertiary amine ∴ no hydrogen bonding to raise its boiling point

35 A 71

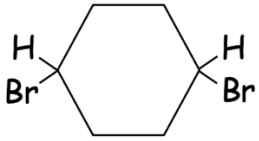
☑A This structure has formula mass of 134, 2x -CH_3 methyl groups and a di-substituted ring
☒B This structure has a tri-substituted benzene ring
☒C $C_{10}H_{12}O$ has a formula mass of 158
☒D This structure does not have two –CH_3 methyl groups

36 B 69

A

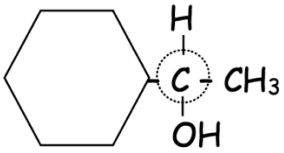


B

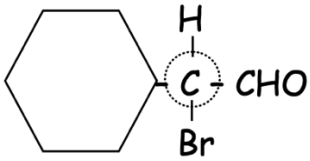


Not chiral because carbons with bromine have 2 identical ring groups regardless of direction

C



D



37 A 76

☑A C_2F_4 is 1,1,2,2-tetrafluoroethene and has no isomers
☒B C_3H_6 has the isomers propene and cyclopropane
☒C C_3H_7Br has the isomers 1-bromopropane and 2-bromopropane
☒D $C_2H_4Cl_2$ has the isomers 1,1-dichloroethane and 1,2-dichloroethane

38 C 72

Answer	A	B	C	D
Formula	$C_4H_6O_2$	$C_6H_6O_2$	$C_8H_8O_2$	C_8H_8O
Mass	(4x12)+(6x1)+(2x16) = 86g	(6x12)+(6x1)+(2x16) = 110g	(8x12)+(8x1)+(2x16) = 136g	(8x12)+(8x1)+(1x16) = 120g
%C	$= \frac{48}{86} \times 100 = 55.8\%$	$= \frac{72}{110} \times 100 = 65.5\%$	$= \frac{96}{136} \times 100 = 70.6\%$	$= \frac{96}{120} \times 100 = 80.0\%$
%H	$= \frac{6}{86} \times 100 = 7.0\%$	$= \frac{6}{110} \times 100 = 5.5\%$	$= \frac{8}{136} \times 100 = 5.9\%$	$= \frac{8}{120} \times 100 = 6.7\%$
%O	$= \frac{32}{86} \times 100 = 37.2\%$	$= \frac{32}{110} \times 100 = 29.1\%$	$= \frac{32}{136} \times 100 = 23.5\%$	$= \frac{16}{120} \times 100 = 13.3\%$

39 D 58

Infra Red Peak	$1715cm^{-1}$	$3300cm^{-1}$
Group	C=O in carboxylic acid	O-H in carboxylic acid

☒A CH_3CHO has no O-H as it is an aldehyde
☒B CH_3COOH ($C_2H_4O_2$) does not have an empirical formula of C_2H_4O
☒C $CH_3COOCH_2CH_3$ is an ester and has no O-H bond
☑D $CH_3CH_2CH_2COOH$ ($C_4H_8O_2$) has an empirical formula of C_2H_4O and has C=O and O-H groups within a -COOH carboxyl group

40 C 38

☒A drug lacks an ionic O^- for ionic interaction with binding site
☒B drug lacks –OH group necessary to be a hydrogen-bond donor
☑C O-CH_3 group on drug accept as a hydrogen bond acceptor
☒D drug lacks –OH group necessary to be a hydrogen-bond donor

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1a

Answer: Octahedral arrangement (square bipyramidal)

Reasoning:

$$\text{No of electron pairs} = \frac{\text{No. of outer electrons in central atom} + \text{No. of bonds} - \text{charge}}{2}$$

$$= \frac{7 + 5 - 0}{2}$$

$$= \frac{12}{2}$$

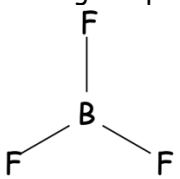
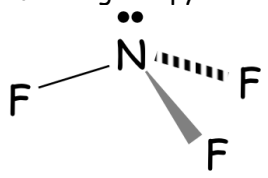
= 6 electron pairs ∴ octahedral arrangement of electrons

1b

Answer: Lone pair of electrons in NF_3 pushes bonds in NF_3 closer together.

BF_3 has no lone pair of electrons

Reasoning:

BF_3 is Trigonal planar	NF_3 is trigonal pyramidal
	
Bond angle in BF_3 is 120° All pairs of electrons are bonding pairs of electrons and the repulsion will be equal	Bond angle in NF_3 is 107° Lone pair to bonding pair repulsion is greater than bonding pair to bonding pair repulsion.

2a

Answer: Green

Reasoning: Light transmitted is the colour seen by the human eye

Colour	Violet	Indigo	Blue	Green	Yellow	Orange	Red
Wavelength	450nm	◄					700nm ►

2b(i)

Answer: +3

Reasoning:

$[CoCl_2(NH_3)_4]^+$

Cl^- is a negatively charged ligand and NH_3 is a neutral ligand

If complex is to have 1+ charge then Cobalt central ion must be Co^{3+} ion

2b(ii)

Answer: Tetraamminedichloridocobalt(III) or Tetramminedichloroidocobalt(III)

Reasoning:

Tetraamminedichloridocobalt(III)

No. of ligands | NH_3 ligand | No. of ligands | chloride ion ligand | metal ion name | Charge on metal ion complex

Ligands listed alphanetically

Neutral ligands include:

Ligand	Name
H_2O	aqua
NH_3	ammine
CO	carbonyl

Negative Ligands include:

Ligand	Name
Chloride Cl^-	chlorido
Cyanide CN^-	cyanido
Nitrite NO_2^-	nitrito

Central Ion:

Positive Complex: metals keep their name

Negative Complex: Metals end in ATE e.g. Cuprate, Ferrate, Cobaltate

Charge:

Charge of central ion is converted into roman numerals and put in brackets

2b(iii)

Answer: $1s^2 2s^2 2p^3 3s^2 3p^6 3d^6$

Reasoning:

Co atom has electron arrangement: $1s^2 2s^2 2p^3 3s^2 3p^6 3d^7 4s^2$

Electrons are removed from the outermost electron shell (4s):

Co^{3+} ion has electron arrangement: $1s^2 2s^2 2p^3 3s^2 3p^6 3d^6$

3a

Answer: Excited electron emit energy when they fall back down to lower energy levels

Reasoning: Electrons are promoted to a higher electron energy level by absorbing energy from the flame. These electrons will return to ground state and the energy released is transmitted as light with a particular wavelength.

3b

Answer: Flame not hot enough or Light emitted is not visible to eye

Reasoning: The promotion of electrons to a higher energy level requires the absorption of energy. It is possible that the Bunsen flame is not hot enough to promote electrons.

If electrons are promoted in Magnesium, the light emitted might by the ultra-violet or infra-red parts of the EM spectrum and not visible to the human eye

3c

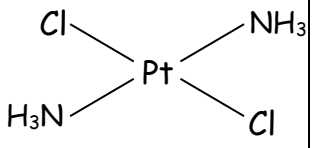
Answer: 178.45 kJ mol^{-1}

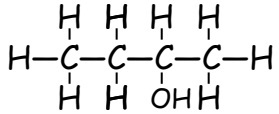
Reasoning:

$$E = \frac{L \times h \times c}{\lambda} = \frac{6.02\times10^{23}\ mol^{-1} \times 6.63\times10^{-34}\ J\ s \times 3\times10^{8}\ m\ s^{-1}}{671 \times 10^{-9} m}$$

$$= 178450\ J\ mol^{-1}$$

$$= 178.45\ kJ\ mol^{-1}$$

4a(i)	DNA co-ordinates to same Pt from 2 different sites	Nitrogen coordinates with Platinum at two different sites/bases as nitrogen atoms have a lone pair of electrons.
4a(ii)	Lone pairs of electrons on Nitrogen	
4b		*trans*-platin: Cl, NH_3, Pt, H_3N, Cl — Cl and NH_3 on opposite sides of Pt *cis*-platin: Cl, Cl, Pt, H_3N, NH_3 — Cl and NH_3 on same sides of Pt
5a(i)	-478 kJ mol^{-1}	ΔH^o = $\Sigma\Delta H_f^o$(products) - $\Sigma\Delta H_f^o$(reactants) = (1x0) + (4x-286) + (1x-1140) - (-1806) = (0 – 1144 – 1140) - (-1806) = (-2284) - (-1806) = -478 kJ mol^{-1}
5a(ii)	217 J K^{-1} mol^{-1}	ΔS^o = ΣS^o(products) - ΣS^o(reactants) = (1x192) + (4x70) + (1x81) - 336 = 192 + 280 + 81 - 336 = 553 - 336 = 217 J K^{-1} mol^{-1}
5a(iii)	-542.7 kJ mol^{-1}	ΔG^o = ΔH^o - $T\Delta S^o$ = (-478) - 298 x $^{217}/_{1000}$ = (-478) - 64.7 = -542.7 kJ mol^{-1}
5b	-570 kJ mol^{-1}	Enthalpy of Formation: The enthalpy change for the formation of one mole of a substance from its element in their natural state. $2Cr_{(s)} + 1\frac{1}{2}O_{2(g)} \longrightarrow Cr_2O_{3(s)}$ ΔH^o=-1140 kJ mol^{-1} (1mol) Enthalpy of Combustion: The enthalpy change for the complete combustion of one mole of a substance $Cr_{(s)} + \frac{3}{4}O_{2(g)} \longrightarrow \frac{1}{2}Cr_2O_{3(s)}$ ΔH^o=-570 kJ mol^{-1} (1mol)
6a	0.001025mol or $1.025x10^{-3}$mol	no. of mol thiosulphate = volume x concentration = 0.0205 x 0.10 = 0.00205 mol $2S_2O_3^{2-} + I_2 \longrightarrow 2I^- + S_4O_6^{2-}$ 2mol 0.00205mol; 1mol 0.001025mol
6b	1.025mol l^{-1}	$ClO^- + 2I^- + 2H^+ \longrightarrow I_2 + Cl^- + H_2O$ 1mol 0.001025mol; 1mol 0.001025mol no. of mol of ClO^- ions in $25cm^3$ of solution = 0.001025mol no. of mol of ClO^- ions in $250cm^3$ of solution = 0.01025mol concentration = $\frac{\text{no. of mol}}{\text{volume}} = \frac{0.01025 \text{ mol}}{0.010 \text{ litres}}$ = 1.025mol l^{-1}
7a	X = 77 kJ mol^{-1} Y = 382 kJ mol^{-1}	Step X: Enthalpy of atomisation for Ca = 178 kJ mol^{-1} Step Y: Enthalpy of 1st Ionisation for Ca = 596 kJ mol^{-1}
7b	Enthalpy of lattice formation	Enthalpy of Lattice of Formation: The energy released when 1 mol of a solid ionic substance is formed from its ions in the gaseous state.
7c	-535.5 kJ mol^{-1}	ΔH = 77 + 77.5 + 382 + (-328) + (-744) = -535.5 kJ mol^{-1}
8a	Starch solution	Starch solution turns blue/black in the presence of iodine

8b(i)	0.0235 mol l^{-1}	no. of mol thiosulphate = volume x concentration = 0.0188 x 0.025 = 0.00047mol $2S_2O_3^{2-} + I_2 \longrightarrow 2I^- + S_4O_6^{2-}$ 2mol 1mol 0.00047mol 0.000235mol $[I_2]_{cyclohexane} = \frac{\text{no. of mol}}{\text{volume}} = \frac{0.000235 \text{ mol}}{0.010 \text{ litres}} = 0.0235 \text{ mol } l^{-1}$
8b(ii)	0.02625 mol l^{-1}	no. of mol thiosulphate = volume x concentration = 0.0105 x 0.050 = 0.000525mol $2S_2O_3^{2-} + I_2 \longrightarrow 2I^- + S_4O_6^{2-}$ 2mol 1mol 0.000525mol 0.0002625mol $[I_2]_{water} = \frac{\text{no. of mol}}{\text{volume}} = \frac{0.0002625 \text{ mol}}{0.010 \text{ litres}} = 0.02625 \text{ mol } l^{-1}$
8c	0.895	$K = \frac{[I_2]_{cyclohexane}}{[I_2]_{water}} = \frac{0.0235 \text{ mol } l^{-1}}{0.02625 \text{ mol } l^{-1}} = 0.895$
8d(i)	Decrease in iodine concentration in water layer	As there is a larger volume of cyclohexane, a larger number of moles of iodine will dissolve in the cyclohexane layer. This means there will be a smaller number of moles of iodine left in the water which would decrease the concentration of iodine in the water.
8d(ii)	No change	Although the concentration of iodine in the water decreases, the concentration of iodine in cyclohexane is also decreases by the same proportion to make no change to the partition coefficient constant $K = \frac{[I_2]_{cyclohexane}}{[I_2]_{water}}$
9a	$K_a = \frac{[H_3O^+][F^-]}{[HF]}$	$K_a = \frac{[H_3O^+][F^-]}{[HF][H_2O]}$ But $[H_2O] = 1$ as water is also the solvent $K_a = \frac{[H_3O^+][F^-]}{[HF]}$
9b	1.58×10^{-4}	Acid is completely neutralised at 14cm^3 NaOH added Half of Acid has been neutralised at 7cm^3 NaOH added $\therefore$ pH of solution at 7cm^3 NaOH added = 3.8 = pK_a $\therefore pK_a$= pH = 3.8 $pK_a = -\log_{10} K_a = 3.8$ $\log_{10} K_a = -3.8$ $K_a = 10^{-3.8} = 1.58 \times 10^{-4}$
9c	F^- ions or NaF	Buffers are created when a weak acid/alkali and a salt of a weak acid/alkali are dissolved in water. HF molecules are the weak acid. Neutralised HF forms the salt sodium fluoride Na^+F^- and this is the salt of a weak acid also required to form a buffer.
9d	Cresol red or alizarin red	At colour change, pH=$pK_{In.}$ Colour change takes place at the steep vertical region of graph (pH=6-9)
10a	Elimination	Elimination reactions remove a small molecule and leave a C=C double bond behind on the reactant.
10b(i)	hybridising/mixing of one s and two p orbitals	sp^2 hybridisation is the mixing of one s-orbital and two p orbitals to form three sigma (σ) bonds. The remaining p-orbital forms a pi (π) bond found in a C=C double bond
10b(ii)	Sigma bond have end-on overlap of orbitals Pi bonds have sideways overlap of orbitals	sp^3 hybridisation is the mixing of one s-orbital and all three p-orbitals to form four sigma (σ) bonds. The bonds are linear with the bond in a straight line with the nuclei.
10c		Markovnikov's Rule: hydrogen becomes attached to the carbon atom of the C=C double bond that is already bonded to the greater number of hydrogen atoms

10d(i) — 2nd order

Experiment	Change	Effect on Rate	Order of reactant
1+2	[1-bromombutane] x2	x2	$[\text{1-bromobutane}]^1$
2+3	$[OH^-]$ x2	x2	$[OH^-]^1$

$\therefore$ Overall order of Reaction = 1 + 1 = 2

10d(ii) — 1.32×10^{-4} l mol^{-1} s^{-1}

Rate = k x $[\text{1-bromobutane}]^1$ x $[OH^-]^1$ = k[1-bromobutane][OH^-]

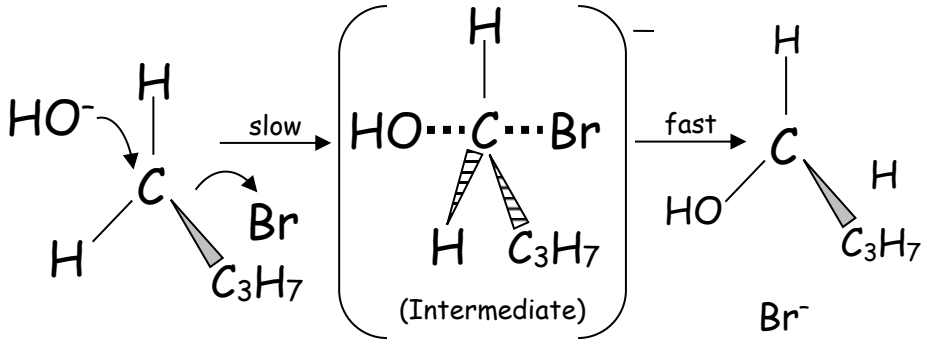
$$\text{rate} = k \times [\text{1-bromobutane}] \times [OH^-]$$

$$k = \frac{\text{rate}}{[\text{1-bromobutane}] \times [OH^-]}$$

$$= \frac{3.3\times10^{-6} \text{ mol } l^{-1} s^{-1}}{0.25 \text{ mol } l^{-1} \times 0.1 \text{ mol } l^{-1}}$$

$$= 1.32\times10^{-4} \text{ l } mol^{-1} s^{-1}$$

10d(iii) — Diagram showing:



11a(i) — Sodium (or other group 1 metal)

$$2C_3H_7OH + 2Na \longrightarrow 2C_3H_7O^-\,Na^+ + H_2$$

propan-1-ol + sodium metal → sodium propoxide + hydrogen

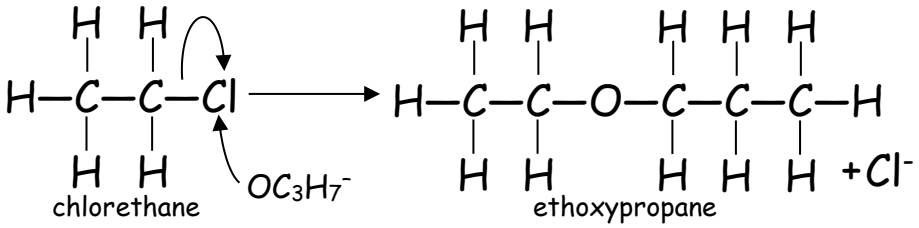
11a(ii) — Acidified dichromate or Hot copper (II) oxide

Propan-1-ol is a primary alcohol which oxidises into propanonic acid

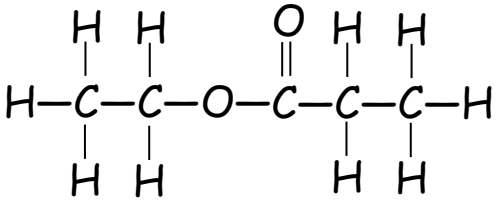
Oxidation of alkanols	❶ Primary alcohol →	Aldehyde
	❷ Secondary alcohol →	Ketone
	❸ Aldehyde →	Carboxylic acid

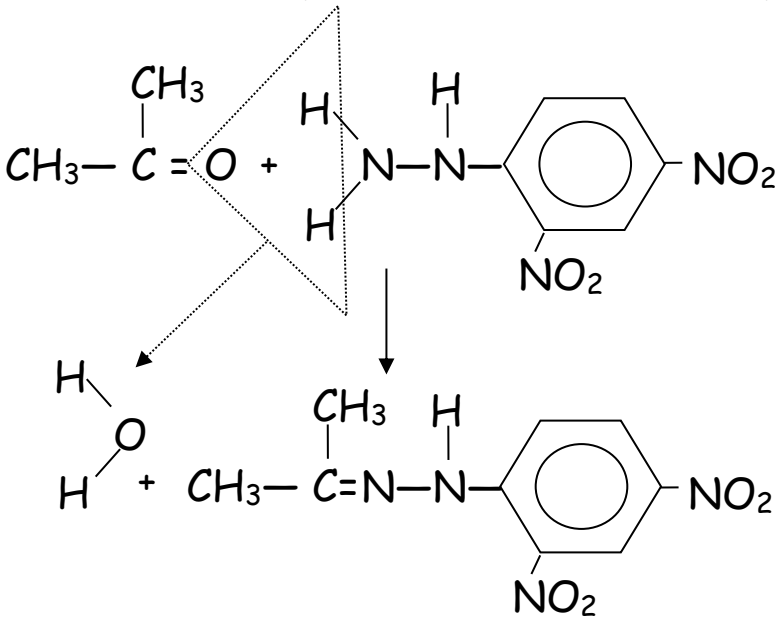
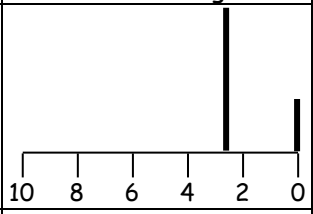
Oxidising agent	Oxidation Types	Start Colour	End Colour
Acidified Dichromate	❶+❷+❸	Orange	Green
Benedict's/Fehling's	❸ only	Blue	Brick Red (orange)
Hot copper (II) oxide	❶+❷+❸	Black	Brown
Tollen's Reagent	❸ only	(Colourless)	Silver mirror produced

11b — Ethoxypropane or ethylpropylether

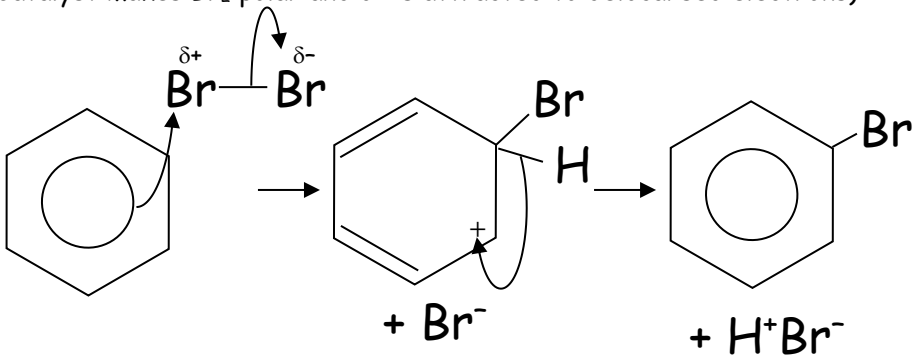


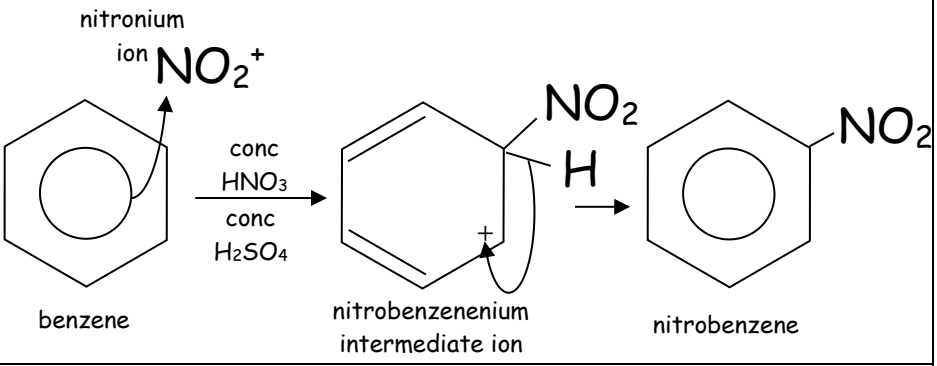
11c — diagram of ethyl propanoate:



<table>
<tr><td>12a</td><td>condensation</td><td><u>Condensation</u>: Two molecules join together with water removed at the join.
  </td></tr>
<tr><td>12b(i)</td><td>recrystallisation</td><td>Recrystallisation will increase the purity because the impurities remain in the solvent.</td></tr>
<tr><td>12b(ii)</td><td>Use of melting point apparatus to measure melting point and checking with data books</td><td>The derivative has a very specific melting point which can be measured accurately in melting point apparatus. Each derivative from an aldehyde or a ketone will melt at a particular temperature which can be looked up in data tables allowing identification of the original aldehyde/ketone</td></tr>
<tr><td>12c(i)</td><td>One of these reagents stating propanone gives no colour change but isomer gives stated colour change</td><td><table>
<tr><th>Reagent</th><th>Start Colour</th><th>End Colour</th></tr>
<tr><td>Acidified Dichromate</td><td>Orange</td><td>Green</td></tr>
<tr><td>Benedict's/Fehling's</td><td>Blue</td><td>Brick Red (orange)</td></tr>
<tr><td>Hot copper (II) oxide</td><td>Black</td><td>Brown</td></tr>
<tr><td>Tollen's Reagent</td><td>(Colourless)</td><td>Silver mirror produced</td></tr>
<tr><td>Acidified Permanganate</td><td>Purple</td><td>Colourless</td></tr>
</table></td></tr>
<tr><td>12c(ii)</td><td> 
</td><td>Chemical Shift Peak must clearly be between 2.0 and 3.0 and not exactly on 3.0

This corresponds to the RCH₂C=O grouping with a chemical shift of 2.3-2.8</td></tr>
<tr><td>12c(iii)</td><td>A: CH_3^+
B: CH_3CO^+</td><td>A has mass= 15: CH_3^+ has mass = (1x12)+(3x1) = 12 + 3 = 15
B has mass= 43: CH_3CO has mass = (2x12)+(3x1)+(1x16) = 24 + 3 + 16 = 43</td></tr>
<tr><td>13a</td><td>electrophillic substitution</td><td><u>Electrophillic</u>: only positive charges are attracted to the high electron density of the benzene ring.
<u>Substitution</u>: one group on and one group off</td></tr>
<tr><td>13b</td><td>Bromine Br_2

$FeBr_3/FeCl_3$ catalyst</td><td>Possible catalysts: $FeBr_3$ or $FeCl_3$ or $AlBr_3$ or $AlCl_3$
(Catalyst makes Br_2 polar and $\delta+$ is attracted to delocalised electrons)
 
</td></tr>
</table>

<table>
<tr>
<td>13c</td>
<td>conc nitric acid
&
conc sulphuric acid</td>
<td>Nitronium ion formed by: $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$
 
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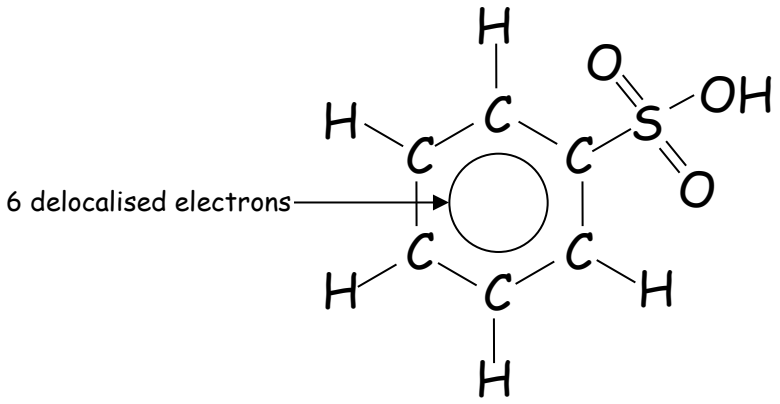
</tr>
<tr>
<td>13d</td>
<td>$C_6H_6SO_3$</td>
<td> 
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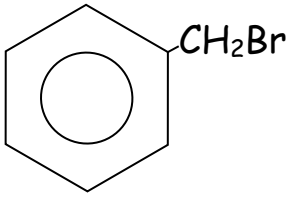
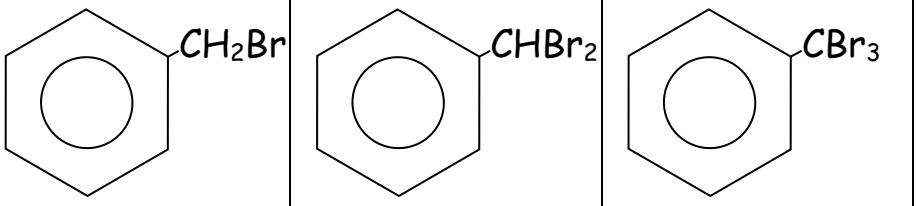
<tr>
<td>13e</td>
<td> 
</td>
<td>Mono, di and tri substituted products will eventually be formed.
 
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