JABchem

Past Papers Advanced Higher Chemistry

2003

Marking Scheme

Grade Awarded	Mark Required	
	(/125)	%
A	91+	73%
B	75+	60%
C	60+	48%
D	?	?
No award	?	?

2003 Adv Higher Chemistry Marking Scheme

MC Qu	Correct Answer	% Correct	Reasoning
1	A	77	☑A β-particles are electrons emitted from a nucleus when a neutron splits into a proton and an electron ☒B *γ-radiation*, X-rays, UV, visible, Infra red, Microwaves, radio & TV are electromagnetic radiation ☒C γ-radiation, X-rays, *Ultraviolet*, visible, IR, Microwaves, radio & TV are electromagnetic radiation ☒D γ-radiation, X-rays, UV, visible, *Infra red*, Microwaves, radio & TV are electromagnetic radiation
2	C	80	Potassium permanganate $KMnO_4$ is purple as magenta/purple light is transmitted. Magenta is a mixture or red & blue light ∴ green light must be absorbed
3	B	69	☒A Melting points decrease down group 1 (data book p6) ☑B Electronegativity increases down group 1 ∴ bigger the Δelectroneg the greater the ionic nature ☒C The 1st ionisation energy decreases down group 1 as atoms become bigger (data book p10) ☒D NaCl has 6:6 co-ordination but CsCl has 8:8 coordination in their lattice structures
4	A	55	☑A $VOF_3 \rightarrow (VO^{3+})(F^-)_3 \rightarrow VO^{3+}$ ion → as O=-2 ∴ V=+5 ☒B $V(OH)_2 \rightarrow V^{2+}(OH^-)_2 \rightarrow V^{2+}$ ion ∴ V=+2 ☒C $VCl_4 \rightarrow V^{4+}(Cl^-)_4 \rightarrow V^{4+}$ ion ∴ V=+4 ☒D $VSO_4.7H_2O \rightarrow V^{2+}SO_4^{2-} \rightarrow V^{2+}$ ion ∴ V=+2 (NB ignore $.7H_2O$)
5	A	63	Maximum absorbance when volume of ligand solution L is twice the volume of the M^+ solution (both 0.1 mol l^{-1}) ∴ Complex is ML_2 (not M_2L). Ligand is neutral so charge on complex is the same as the charge on the metal ion M^+ ∴ $[ML_2]^+$
6	D	80	☒A Pauli Exclusion Principle: No electron has the same 4 quantum numbers ☒B Heisenberg Uncertainty: momentum and position of an electron cannot be defined at same instant ☒C Aufbau principle: Orbitals fill up in order of lowest energy (1s,2s,2p,3s,3p,4s,3d,4p,5s,4d,5p,6s,4f, etc) ☑D Hund's Rule: orbitals fill up single rooms first to maximise the number of parallel spins
7	D	60	Co atom electron arrangement: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$ or $[Ar]\ 4s^2\ 3d^7$ Co^{2+} ion electron arrangement: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7$ or $[Ar]\ 3d^7$ (NB 4s electrons removed first)
8	D	29	$2Zn + O_2 \rightarrow 2ZnO$: production of Zn is the reverse reaction. Upper line is reversed on Ellingham diagrams. $2Zn + O_2 \rightarrow 2ZnO$ becomes the upper line at temperatures above 1400°C At 1400°C, decomposition of ZnO becomes feasible and ZnO starts to decompose to form Zn
9	B	46	**no**. of moles of NO_3^- ion = **v**olume x **c**oncentration = 0.5l x 0.1mol l^{-1} = 0.05mol NO_3^- ions But 1 $Ca(NO_3)_2$ formula unit releases 2 NO_3^- ions ∴ no of moles $Ca(NO_3)_2$ needed = 0.025mol $\text{volume} = \frac{\text{no. of mol}}{\text{concentration}} = \frac{0.025\text{ mol}}{0.25\text{ mol } l^{-1}} = 0.1\text{ litres} = 100cm^3$
10	D	67	Ammonium dichromate = $(NH_4)_2Cr_2O_7$ Decomposition reaction: $(NH_4)_2Cr_2O_7 \longrightarrow Cr_2O_3 + N_2 + 4H_2O$
11	C	51	☒A $BaCl_2$ is ionic ∴ no atoms present ☒B $BaCl_2$ is ionic ∴ no molecules present ☑C $BaCl_2$ is $Ba^{2+}(Cl^-)_2$ ∴ 1 mol $BaCl_2$ formula units contains 1 mol of positive Ba^{2+} ions ☒D $BaCl_2$ is $Ba^{2+}(Cl^-)_2$ ∴ 1 mol $BaCl_2$ formula units contains 1 mol of positive Ba^{2+} ions
12	D	62	**no**. of moles of $K_2Cr_2O_7$ = **v**olume x **c**oncentration = 0.025 x 0.1 = 0.0025mol $Cr_2O_7^{2-}$ ions Equation ❶: $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ Equation ❷x6: $6Fe^{2+} \rightarrow 6Fe^{3+} + 6e^-$ Add ❶+❷': $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$ 1mol 6mol 0.0025mol 0.015mol
13	A	76	☑A removal of H^+ by neutralisation ∴ removal of product ∴ more forward reaction (dissociation) ☒B addition of H^+ ∴ addition of product ∴ more reverse reaction to remove product ☒C addition of catalyst would not change proportions of products at equilibrium ☒D addition of $H_2PO_4^-$ ∴ addition of product ∴ more reverse reaction to remove product
14	C	63	$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ 1mol 1mol 1mol But equilibrium concentration of PCl_5 = 0.5 mol 0.5mol 0.5mol 0.5mol Final volume = 0.5mol PCl_5 remaining + 0.5 mol PCl_3 produced + 0.5mol Cl_2 produced = 1.5mol gas

15	A	76	Titration of weak acid (CH_3COOH) and strong alkali (NaOH) ∴ neutralisation occurs at alkaline pH (i.e. pH>7) ∴ Indicator used should be at pH range above 7
16	B	63	☒A as acid is diluted, pH increases to pH=7 ☑B [H^+] decreases as acid is diluted ☒C pK_a remains constant during dilution ☒D degree of dissociation remains constant during dilution
17	B	51	☒A [OH^-] = 10^{-14} ∴ [H^+] = 10^0 ∴ pH=0 ☑B [OH^-] = 10^0 ∴ [H^+] = 10^{-14} ∴ pH=14 ☒C [OH^-] = 10^1 ∴ [H^+] = 10^{-15} ∴ pH=15 ☒D [OH^-] = 10^{14} ∴ [H^+] = 10^{-28} ∴ pH=28 (obviously not the correct answer)
18	D	72	☒A Bond enthalpy equation should only break O–H bonds. (H_2 in equation ∴H-H bond is formed) ☒B $H_2O \rightarrow O + 2H$ is breaking 2x O-H bonds ∴ ΔH = 2x O-H bond enthalpy = 2X ☒C Bond enthalpy equation should only break O–H bonds. (H_2 in equation ∴H-H bond is formed) ☑D $H_2O \rightarrow O + 2H$ is breaking 2x O-H bonds ∴ ΔH = 2x O-H bond enthalpy = 2X
19	D	49	☒A ΔH_2: $Na(s) \rightarrow Na(g)$ = enthalpy of atomisation of sodium = +107kJ mol^{-1} ☒B ΔH_3: $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$ = ½x bond enthalpy of chlorine = ½x 243 = +121.5kJ mol^{-1} ☒C ΔH_4: $Cl(g) + e^- \rightarrow Cl^-(g)$ = enthalpy of electron affinity = -349kJ mol^{-1} ☑D ΔH_5: $Na(g) \rightarrow Na^+(g) + e^-$ = enthalpy of 1st ionisation = +496kJ mol^{-1}
20	D	79	☒A ΔH_3 is endothermic ☒B ΔH_4 is exothermic ☒C ΔH_5 is endothermic ☑D ΔH_6 is enthalpy of lattice formation which is always exothermic and large
21	D	65	☒A not enough information to make decision (need information on slow RDS step) ☒B overall order is 3rd order (1+2=3) ☒C Order of Q = 2nd order ∴ double [Q] → rate increase x4 ☑D In all reactions, as reaction proceeds the reaction slows down.
22	C	58	$\begin{array}{ccccc} \Delta G^o & = & \Delta H^o & & -T \times \Delta S^o \\ \underbrace{\text{negative value}} & & X & & -T \times \underbrace{(\text{negative } \Delta S^o)} \\ \text{negative value} & = & X & + & (\text{positive value}) \end{array}$ ∴ ΔH^o = X = (negative value) – (positive value) = negative value = exothermic
23	B	93	Electrons flow from metal M to Ag in diagram ❶x-1 $M \rightarrow M^{2+} + 2e^-$ $E^o = X$ ❷x2 $2Ag^+ + 2e^- \rightarrow 2Ag$ $\underline{E^o = 0.80V}$ ❶'+❷' $M + 2Ag^{2+} \rightarrow M^{2+} + 2Ag$ $\underline{E^o = 1.03V}$ 0.8V + X = 1.03V ∴ X = 0.8V - 1.03V = +0.23V ∴ $M^{2+} + 2e^- \rightarrow M$ $E^o = -0.23V$ ∴ M is Nickel Ni (p12 databooklet) (in old data booklet Ni^{2+} was 0.23V now 0.26V)
24	D	70	E^o = 1.03V: $M + 2Ag^{2+} \rightarrow M^{2+} + 2Ag$ where 2 mol of e^- are transferred in redox reaction: $\Delta G^o = -nFE^o = -2 \times 96500 \times 1.03 = -198790\ J\ mol^{-1} = -198.8kJ\ mol^{-1}$
25	C	48	$Cl^-_{(aq)}$ ions from salt bridge will precipitate with $Ag^+_{(aq)}$ ions in beaker to form $Ag^+Cl^-_{(s)}$ in the salt bridge which could stop the salt bridge from completing the circuit effectively.
26	D	82	Positive entropy change ΔS^o is an increase in entropy ∴ an increase in disorder ☒A Decrease in disorder as H_2O molecules become very ordered as they freeze and line up. ☒B Two gases becoming a solid is a decrease in disorder ☒C Many gas monomer molecules becoming one large solid polymer is a decrease in disorder ☑D Solid NH_4NO_3 becoming three gases is a large increase in disorder
27	B	40	☒A Amino $-NH_2$ group would react with acid but not alkali ☑B Amino $-NH_2$ group would react with $HCl_{(aq)}$ and carboxyl $-COOH$ group would react with $NaOH_{(aq)}$ ☒C Amine $-NH_2$ group would react with acid but not alkali ☒D Substituted ammonium ion ($CH_3CH_2NH_3^+$) will react with alkali but not acid

28	D	53	☒A $C_4H_9NH_2$: Primary Amine → two N–H bonds → hydrogen bonding ∴ raised boiling point ☒B $C_3H_7NHCH_3$: Secondary Amine → N–H bond → hydrogen bonding ∴ raised boiling point ☒C $C_2H_5NHC_2H_5$: Secondary Amine → N–H bond → hydrogen bonding ∴ raised boiling point ☑D $C_2H_5N(CH_3)_2$: Tertiary Amine → no N–H bonds→ no hydrogen bonding ∴ lower boiling point
29	B	71	There are no C=C double bonds for addition reactions in methane and chlorine. Homolytic fission, free radical formation and a chain reaction are all found in the reaction of methane with chlorine.
30	A	57	☑A Lower melting point of oils caused by shape of C=C double bonds keeping oil molecules apart ☒B Pure ethanoic acid molecules have hydrogen bonding between the –COOH groups in their *di*mers ☒C methanol has hydrogen bonding due to its –OH group but alkanes have no hydrogen bonding ☒D propanone is miscible (mixes) with water as the hydrogen bonding of water interacts with Propanone due to similar shape and polar carbonyl group. NB pure propanone has no hydrogen bonding.
31	D	70	☒A methoxymethane (ether) is more volatile than ethanol (ethers have lower boiling points than alkanols) ☒B ethers are not as reactive when compared to alkanols ☒C Ethers have peak at $1070\text{-}1150cm^{-1}$ (C-O-C) and alkanols have a peak at $3200\text{-}3570cm^{-1}$ (-OH group) ☑D Both have formula C_2H_6O ∴ burn to form same products: $C_2H_6O + 3O_2 \rightarrow 2CO_2 + 3H_2O$
32	A	81	<table><tr><td>Bond Type</td><td>C – C</td><td>C = C</td><td>C ≡ C</td><td>C – H</td></tr><tr><td>Sigma σ</td><td>1</td><td>1</td><td>1</td><td>1</td></tr><tr><td>Pi π</td><td>0</td><td>1</td><td>2</td><td>0</td></tr></table> 4xC-H + 1xC-C + 1xC=C + 1xC≡C (4σ) + (1σ) + (1σ+1π) + (1σ+2π) = 7σ + 3π
33	B	42	☒A nucleophiles are attracted to the δ+ carbon atom of the polar C-Br bond in CH_3CH_2Br (S_N2) ☑B Electrophiles, not nucleophiles, are attracted to the delocalised electrons in the benzene ring of C_6H_5Br ☒C nucleophiles are attracted to the positively charged carbocation intermediate $(CH_3)_3C^+$ (S_N1) ☒D nucleophiles are attracted to the δ+ carbon atom of the polar C-Cl bond in $(CH_3)_2CHCl$ (S_N2)
34	C	55	☒A Aldehydes oxidise to form alkanoic acids. Alkanoic acids are acidic when dissolved in water. ☒B Ketones do not oxidise with hot copper (II) oxide. ☑C Secondary alcohols oxidise to form ketones. Ketones are neutral if dissolved in water. ☒D Tertiary alcohols do not oxidise with hot copper (II) oxide.
35	A	83	Tertiary halogenalkanes have 3 carbons directly attached to the carbon bonded to the halogen. ☑A $(CH_3)_3CBr$ is tertiary: 3 carbons directly attached to the carbon bonded to the halogen ☒B $CHBr_3$ has no carbons attached to the carbon with the halogen bond (i.e. not a tertiary halgoenalkane) ☒C $CH(CH_2Br)_3$: each C in a C-Br bond has 1 carbon attached to the carbon with the Br atom. ☒D $(CH_3)_3CCH_2Br$ is primary: 1 carbon directly attached to the carbon bonded to the halogen
36	A	92	Every corner is a carbon (14 corners → C_{14}). Every 2 point corner has a C-H bond (10x 2point corners → H_{10})
37	C	70	☒A The delocalised electrons in benzene attract electrophiles ☒B $H_2SO_4 + HNO_3$ produces NO_2^+ ions which electrophilically attack the benzene ring ☑C $H_2SO_4 + HNO_3$ produces NO_2^+ ions which electrophilically attack the benzene ring ☒D no oxidation of HNO_3 in mechanism
38	A	37	CH_3Cl heterolytically splits to form CH_3^+ ions in the presence of $AlCl_3$ catalyst. CH_3^+ electrophilically attack benzene ring and substitute onto the ring.
39	A	75	Markovinok's Rule: H atom of HCl adds onto the C in the C=C bond which has the higher number of hydrogens already attached to it: 2-methylpent-2-ene + HCl → 2chloro-2-methylpentane H adds onto C_3 in 2-methylpent-2-ene (C_3has 1 hydrogen atom attached to it) Cl adds onto C_2 in 2-methylpent-2-ene (C_2 has no hydrogens attached to it)
40	C	54	❶ $2C(s) + 2H_2(g) \longrightarrow C_2H_4(g)$ Enthalpy of formation for ethane **(data required)** ❷ $C(s) \longrightarrow C(g)$ Enthalpy of sublimation (atomisation) **(data required)** ❸ $H_2(g) \longrightarrow 2H(g)$ Bond Enthalpy for H_2 **(data required)** ❶x-1 $C_2H_4(g) \longrightarrow 2C(s) + 2H_2(g)$ ❷x2 $C(s) \longrightarrow C(g)$ ❸x2 $H_2(g) \longrightarrow 2H(g)$ ❶'+❷'+❸' $C_2H_4(g) \longrightarrow 2C(g) + 4H(g)$ Equals the bond enthalpies for: 4xC-H + 1xC=C **(data required)** to be calculated

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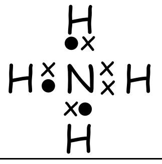
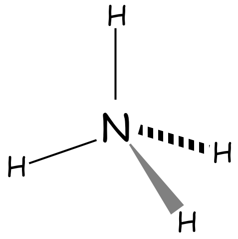
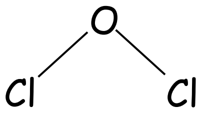
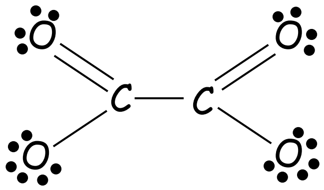
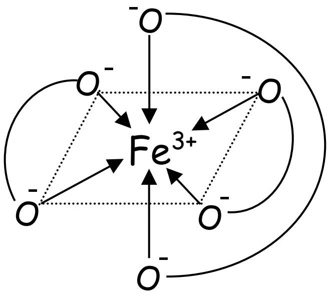
Long Qu	Answer	Reasoning
1a	Same atom provides both electrons in a bond	A dative covalent bond is when a lone pair on an atom provides both the electrons which are shared between two atoms in a covalent bond e.g. $H^+ + :NH_3 \longrightarrow NH_4^+$
1b		where x is electron from N and ● is electron from H
1c		All 4 bonds (including the dative covalent bond) are equal and indistinguishable from each other. The tetrahedral shape formed has a bond angle of 109.5° between all of the bonds. Positive charge spread evenly over whole ion
2a	0.0055mol	**n**o. of mol NaOH = **v**olume x **c**oncentration = 0.0081 x 0.11 = 0.000891mol $NaOH + HCl \longrightarrow NaCl + H_2O$ 1mol 1mol 0.000891mol 0.000891mol Total **no.** of mol HCl = **v** x **c** = 0.04 litres x 0.16 mol l^{-1} = 0.0064mol **n**o. of mol of HCl not used in neutralisation of $MgCO_3$ = 0.000891mol **n**o. of mol of HCl used in neutralisation of $MgCO_3$ = 0.0064 – 0.000891 = 0.005509mol
2b(i)	$MgCO_3 + 2HCl$ ↓ $MgCl_2 + H_2O + CO_2$	$MgCO_3 + 2HCl \longrightarrow MgCl_2 + H_2O + CO_2$
2b(ii)	92.8%	1 mol $MgCO_3$ = (1x24.3)+(1x12)+(3x16) = 24.3+12+48 = 84.3g $MgCO_3 + 2HCl \longrightarrow MgCl_2 + H_2O + CO_2$ 1mol 2mol 0.002755mol 0.005509mol **m**ass = **n**o. of mol x **gfm** = 0.002755mol x 84.3g = 0.2322g $MgCO_3$ $\%purity = \frac{mass\ of\ pure}{mass\ of\ impure} \times 100 = \frac{0.2322}{0.25} \times 100 = 92.8\%$
3a	SiO_2	SiO_2 is the only covalent network oxide in the table: ☑high melting point ☑non-metals only in oxide
3b(i)	Can react as an acid or a base	Al_2O_3 is amphoteric as it reacts as an acidic oxide and a basic oxide e.g. as a base: $Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$ as an acid: $Al_2O_3 + 3H_2O + 2NaOH \longrightarrow 2NaAl(OH)_4$
3b(ii)	Al_2O_3	
3c		$\text{No of electron pairs} = \frac{\text{No. of outer electrons in central atom} + \text{No. of bonds} - \text{charge}}{2}$ $= \frac{6+2-0}{2}$ $= \frac{8}{2}$ = 4 electron pairs ∴ tetrahedral arrangement of electrons 2 bonding pairs and 2 lone pairs ∴ angluar shape

<table>
<tr><td>4a</td><td>6</td><td>
Oxalate $C_2O_4^{2-}$ ion is a bidentate ligand
3 oxalate ions surround Fe^{3+} ion
co-ordination number=6</td></tr>
<tr><td>4b</td><td>Acts as oxidising agent
(oxidises $Fe^{2+} \rightarrow Fe^{3+}$)</td><td>$Fe^{2+}(C_2O_4)^{2-}$ has Fe^{2+} ions
$K_3[Fe(C_2O_4)_3]$ and $Fe(OH)_3$ both contain Fe^{3+} ions
Oxidation: $Fe^{2+} \rightarrow Fe^{3+} + e^-$ carried out by an oxidising agent</td></tr>
<tr><td>4c</td><td>1 mol</td><td>$(NH_4)_2Fe(SO_4)_2 + H_2C_2O_4 \longrightarrow FeC_2O_4 + (NH_4)_2SO_4 + H_2SO_4$
1mol → 1mol
6mol → 6mol
$6FeC_2O_4 + 3H_2O_2 + 6K_2C_2O_4 \longrightarrow 4K_3Fe(C_2O_4)_3 + 2Fe(OH)_3$
6mol → 4mol, 2mol
$2Fe(OH)_3 + 3H_2C_2O_4 + K_2C_2O_4 \longrightarrow 2K_3Fe(C_2O_4)_3 + 3H_2O$
2mol → 2mol
∴ 6 mol $FeSO_4(NH_4)_2SO_4 \longrightarrow$ 6 mol $K_3Fe(C_2O_4)_3$
1 mol $FeSO_4(NH_4)_2SO_4 \longrightarrow$ 1 mol $K_3Fe(C_2O_4)_3$</td></tr>
<tr><td>4d</td><td>19%</td><td>1mol $(NH_4)_2Fe(SO_4)_2.6H_2O$ = (2x14)+(8x1)+(1x55.8)+(2x32.1)+(8x16)+(6x18)
= 28+8+55.8+64.2+128+108 = 392g
1mol $K_3Fe(C_2O_4)_3.3H_2O$ = (3x39.1)+(1x55.8)+(6x12)+(12x16)+(3x18)
= 117.3+55.8+72+192+54 = 491.1g
$(NH_4)_2Fe(SO_4)_2.6H_2O \longleftrightarrow K_3Fe(C_2O_4)_3.3H_2O$
1mol ⟷ 1mol
392g ⟷ 491.1g
5g ⟷ 491.1g x $^5/_{392}$
= 6.3g (theoretical 100% yield)
$\% \text{ Yield} = \frac{\text{Actual}}{\text{Theoretical}} \times 100 = \frac{1.2}{6.3} \times 100 = 19\%$</td></tr>
<tr><td>5a(i)</td><td>$LiAlH_4$
lithium aluminium hydride</td><td>Oxidation: butan-1-ol (B) ⟶ butanal (A)
∴ Reduction: butanal (A) ⟶ butan-1-ol (B)</td></tr>
<tr><td>5a(ii)</td><td>HBr
hydrogen bromide</td><td>HBr adds across the C=C double bond:
but-1-ene + hydrogen bromide ⟶ 2-bromobutane</td></tr>
<tr><td>5b(i)</td><td>Dehydration
or elimination</td><td>H_2O is eliminated between 2 carbons forming a C=C double bond</td></tr>
<tr><td>5b(ii)</td><td>Oxidation</td><td>Oxidation: secondary alcohol ⟶ ketone
butan-2-ol ⟶ butanone</td></tr>
<tr><td>5c</td><td>1-bromobutane</td><td>The major product according to Markovnikov's Rule will be 2-bromobutane as the H of HBr will add to C_1 as C_1 has more H atoms already attached to it. However, some H will add to C_2 meaning Br will add to C_1 creating the minor product 1-bromobutane.</td></tr>
<tr><td>5d</td><td>One from:
Benedict's Solution
Fehling's Solution
Tollen's Reagent
Acidified Dichromate
Acidified permanganate
(hot) copper (II) oxide</td><td>
<table>
<tr><th>Oxidising Agent</th><th>primary alcohol
↓
aldehyde</th><th>secondary alcohol
↓
ketone</th><th>aldehyde
↓
carboxylic acid</th></tr>
<tr><td>acidified dichromate</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>acidified permanganate</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>hot copper (II) oxide</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Tollen's Reagent</td><td>×</td><td>×</td><td>✓</td></tr>
<tr><td>Benedict's/Fehling's Solution</td><td>×</td><td>×</td><td>✓</td></tr>
</table>
</td></tr>
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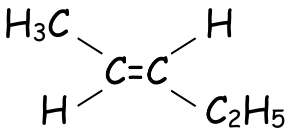
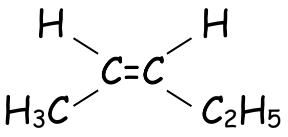
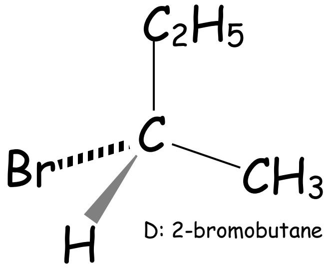
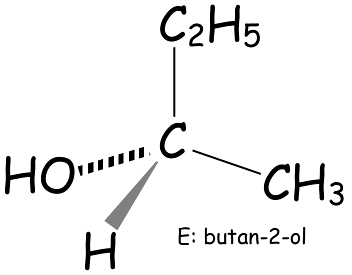
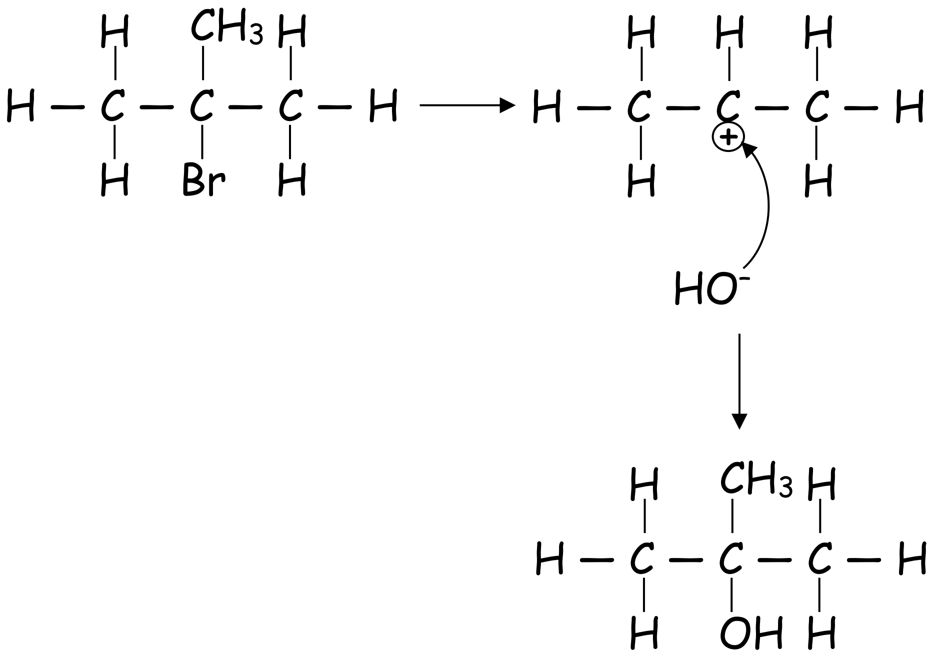
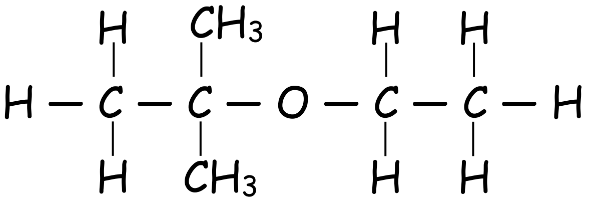
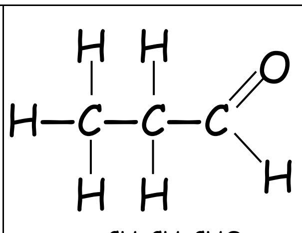
5e(i)	Both atoms on one side of C=C double bond are the same	For trans- and cis- geometric isomers, each end of the C=C double bond must have two different groups.  trans-pent-2-ene  cis-pent-2-ene
5e(ii)	D and E	D  D: 2-bromobutane E  E: butan-2-ol
6a(i)	Nucleophilic substitution	S_N1: Nucleophilic substitution with 1 particle involved in (slow) rate determining step S_N2: Nucleophilic substitution with 2 particles involved in (slow) rate determining step
6a(ii)	1 mark structural formula of reactant & product 1mark structure of intermediate	
6b	Carbocation intermediate is not stable enough to exist	The carbocation produced by the heterolytic splitting of the C-Br bond in 1-bromobutane is not stable enough for it to be a viable route for reaction.
6c	Any diagram showing:	
7a	C=O (carbonyl)	The C=O group in an aldehyde (RCHO) causes an adsorption at 1730cm^{-1}
7b	$C_2H_5^+$ or CHO^+ (accept: C_2H_5 or CHO)	C_2H_5 = (2x12)+(5x1) = 24+5 = 29 CHO = (1x12)+(1x1)+(1x16) = 12+1+16 = 29
7c	X:Y:Z = 3:2:1	Areas under peak are multiples of 25

<table>
<tr><td>7d</td><td>
or CH_3CH_2CHO</td><td>
<table>
<tr><th>Evidence from</th><th>Reasoning</th></tr>
<tr><td>part(a) IR spec</td><td>Peak at 1730cm^{-1} $\therefore$ CHO group</td></tr>
<tr><td>part(b) Mass spec</td><td>C_2H_5- group and CHO- groups both weigh 29</td></tr>
<tr><td>Part (c) NMR</td><td>
<table>
<tr><th>Chemical Shift</th><th>No. of H atoms</th><th>Group</th></tr>
<tr><td>1.1</td><td>3</td><td>$-CH_3$</td></tr>
<tr><td>2.5</td><td>2</td><td>$-CH_2-$</td></tr>
<tr><td>9.8</td><td>1</td><td>-CHO</td></tr>
</table>
</td></tr>
</table>
</td></tr>
<tr><td>7e</td><td>Forms a solid (derivative) which has certain melting point</td><td>Brady's Reagent forms a white crystalline derivative solid with aldehydes and ketones only which distinctive melting points which can be measured on melting point apparatus.</td></tr>
<tr><td>8a</td><td>Answer should include:</td><td>Agonists bind with the active site and produces a biological response.
Antagonists bind with the active site and inhibit a biological response.</td></tr>
<tr><td>8b</td><td>Answer should include:</td><td>Pharmacophores are the specific shape of a chemical which fits into a receptor to cause or inhibit a biological response. Molecules which fit the receptor have the same pharmacophore shape whether it gives the biological response inside the cell or not.</td></tr>
<tr><td>9a</td><td>Rate = k $[H_2O_2][I^-]$</td><td>
<table>
<tr><th>Experiments</th><th>Change in conditions</th><th>Effect on Rate</th><th>Order</th></tr>
<tr><td>1+2</td><td>$[H_2O_2] \times 2$</td><td>x2</td><td>$[H_2O_2]^1$</td></tr>
<tr><td>1+3</td><td>$[I^-] \times 2$</td><td>x2</td><td>$[I^-]^1$</td></tr>
<tr><td>1+4</td><td>$[H^+] \times 2$</td><td>No change</td><td>$[H^+]^0$</td></tr>
</table>
Rate = k $[H_2O_2]^1[I^-]^1[H^+]^0$ $\therefore$ Rate = k $[H_2O_2][I^-]$</td></tr>
<tr><td>9b</td><td>2.3×10^2 l mol^{-1} s^{-1}</td><td>Rate = k $[H_2O_2][I^-]$
$$k=\frac{rate}{[H_2O_2][I^-]} = \frac{2.07\times10^{-3}\text{ mol l}^{-1}\text{ s}^{-1}}{(0.3\text{ mol l}^{-1})\times(0.3\text{ mol l}^{-1})} = 2.3\times10^2\text{ l mol}^{-1}\text{ s}^{-1}$$</td></tr>
<tr><td>10a</td><td>-81.2</td><td>$\Delta S^o = \sum S^o(\text{products}) - \sum S^o(\text{reactants})$
$= (2\times69.9) + (213.8) - (127.0 + (1.5\times205.2))$
$= 353.6 - 434.8 = -81.2\text{ J K}^{-1}\text{ mol}^{-1}$</td></tr>
<tr><td>10b</td><td>-720.8</td><td>$\Delta G^o = \Delta H^o - T\Delta S^o$
$= -727 - (298 \times {}^{-81.2}/_{1000})$
$= -727 - (-24.2)$
$\Delta G^o = -720.8\text{ kJ mol}^{-1}$</td></tr>
<tr><td>10c</td><td>$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$</td><td>
<table>
<tr><td>Redox Reaction</td><td>CH_3OH</td><td>+</td><td>$^3/_2O_2$</td><td>$\rightarrow$</td><td>CO_2</td><td>+</td><td>$2H_2O$</td></tr>
<tr><td>Separate half-equations</td><td>CH_3OH</td><td>+</td><td>$^3/_2O_2$</td><td>$\rightarrow$
$\rightarrow$</td><td>CO_2</td><td>+</td><td>$2H_2O$</td></tr>
<tr><td colspan="8">From Data Booklet:</td></tr>
<tr><td>Balance reduction reaction</td><td>$4H^+ + 4e^-$</td><td>+</td><td>O_2</td><td>$\rightarrow$</td><td></td><td>+</td><td>$2H_2O$</td></tr>
</table>
</td></tr>
<tr><td>10d</td><td>H^+ ion</td><td>H^+ ions are products in the oxidation reaction
H^+ ions are reactants ion the reduction reaction</td></tr>
<tr><td>11a</td><td>2.80</td><td>pH = $\frac{1}{2}pK_a - \frac{1}{2}\log_{10}c$
$= \frac{1}{2}(4.9) - \frac{1}{2}\log_{10}(0.2)$
$= 2.45 - (-0.35)$
$= 2.80$</td></tr>
<tr><td>11b</td><td>Answer should include:</td><td>A buffer had been created.
Octanoate ions created by partial neutralisation with NaOH will mop up H^+ ions from the added HCl solution: Octanoate ions + H^+ $\rightleftharpoons$ Octanoic acid</td></tr>
<tr><td>12a</td><td>3×10^{-6}
or 0.000003</td><td>$$K_{In}=\frac{[H^+][In^-]}{[HIn]} = \frac{10^{-7}\times(3.9\times10^{-4})}{1.3\times10^{-5}} = 3\times10^{-6}$$</td></tr>
<tr><td>12b</td><td>Yellow</td><td>At pH > 7, $[In^-]>[HIn]$ as H^+ ions have reacted with alkali
At pH < 7, $[HIn] >[In^-]$ as H^+ ions have joined up with In^- ions</td></tr>
</table>