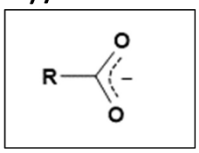
Course 2- Organic Chemistry Long Q's

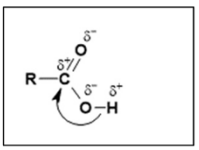
Marking scheme

Question 1

QUESTION 8

(*a*) (*i*) EXPLAIN: –COOH (RCOOH) **loses (donates) proton (H^+) forming $–COO^–$ ($RCOO^–$) /**
–COOH (RCOOH) **dissociates forming $–COO^–$ ($RCOO^–$) and proton (H^+, H_3O^+) //**

($–COO^–$) stable (exists as **resonance** hybrid**) /**
delocalised charge on $–COO^–$ ($RCOO^–$) /  **/**

inductive effect draws electrons away from H of **OH** bond **/**  **/**

δ^+ carbonyl carbon draws electrons away from H of **OH** bond (2 × 3)
[R in boxes need not be shown explicitly.]
[Allow carboxylate ion for **$–COO^–$** or **$RCOO^–$]**

(*ii*) GIVE: **reaction with sodium (or other alkali metal) /**
Na (K) + C_2H_5OH → (6)
[No marks deducted for incorrect product.]

(*iii*) WHAT: **nothing / no reaction / no** (3)

EXPLAIN: ethanol **not strong**ly **acid**ic **/** ethanol **weak**ly **acid**ic **/**
Na_2CO_3 not strongly **basic enough / no resonance stabilisation**
in ethoxide ion / no inductive effect in ethanol (3)
[EXPLAIN marks available only if WHAT marks awarded.]

(*b*) (*i*) WRITE: **$HCOOH + C_2H_5OH \rightarrow HCOOC_2H_5 + H_2O$ /**
$HCO_2H + C_2H_5OH \rightarrow HCO_2C_2H_5 + H_2O$ FORMULAE: (3) BALANCING: (3)
[Accept CH_2O_2 for methanoic acid, C_2H_6O for ethanol and $C_3H_6O_2$ for ethyl methanoate]

(*ii*) GIVE: **ethyl methanoate** ✔

(*iii*) HOW MANY: **one / 1** ✔

(*iv*) CLASSIFY: **substitution** ✔

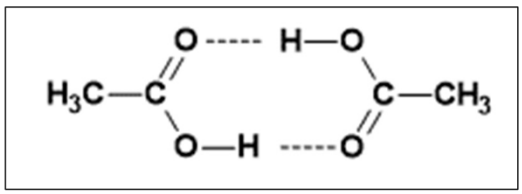
(*v*) IDENTIFY: **methyl ethanoate (CH_3COOCH_3)** ✔

(*vi*) IDENTIFY: **methanol / CH_3OH //**
sodium methanoate / HCOONa ✔ ✔

(*vii*) EXPLAIN: **hydrogen (H) bonds** in ethanoic acid **/**
no hydrogen (H) bonds in methyl methanoate /

dipole-dipole (van der Waals, London, dispersion) forces (bonds, interactions) in methyl methanoate /

ethanoic acid (the carboxylic acid) **dimerises /**
effective **molecular formula** ethanoic acid **$C_4H_8O_4$ /**
ethanoic acid **forms (becomes) $(CH_3COOH)_2$ /**
effective **molecular mass (M_r)** ethanoic acid **increased (**is **120) /**



✔

(*ii*) to (*vii*) has SEVEN POINTS: [(2 × 6) + (4 × 3) + 2]

Question 2

(*b*) WHAT: (*i*) purple (violet, pink) to **colourless** (6)
[Decolourises sufficient.][Clear unacceptable.]

WHAT: (*ii*) blue solution to brick **red precipitate (solid)** (3)

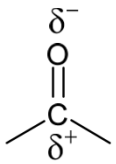
(*iii*) IDENTIFY: **ethanoic acid (CH_3COOH) / ethanoate** ion **(CH_3COO^-) / sodium ethanoate (CH_3COONa)** (3)

(*iv*) IS: ethanal very **easily** oxidised **/** ethanal **easy** to oxidise (3)

(*v*) WRITE: **$Cu^{2+} + e^- \rightarrow Cu^+$** (3)

(*vi*) DESCRIBE: **carbon (C) is partially (slightly) positive**ly charged **/ carbon (C) is δ^+ // oxygen (O) is partially (slightly) negative**ly charged **/ oxygen (O) is δ^-** (2 × 2)

or



(4)

(*vii*) EXPLAIN: **hydrogen bonding (attraction) between δ^- oxygens of ethanal and δ^+ hydrogens of water /**
attraction (intermolecular forces, intermolecular bonding, dipole-dipole interactions) between δ^+ carbon of ethanal and δ^- oxygen of water (partial charges of ethanal and water) (3)
[Information acceptable in diagrammatic form, labels not essential]

Question 3

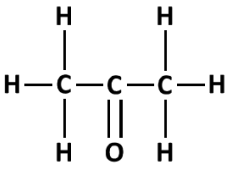
QUESTION 8

(*a*) (*i*) WHAT NAME: **propan-2-ol / 2-propanol**

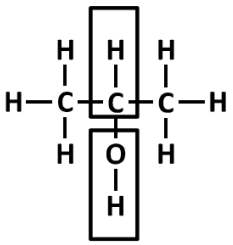
(*ii*) CLASSIFY: **secondary / 2^{o}**

JUSTIFY: **two carbon** atoms **attached to carbon (C) with OH /**
OH (alcohol functional **group) attached to carbon in middle of chain (carbon 2, C2, carbon with only one H atom attached to it) /**
OH (alcohol functional **group) not on terminal (end, first, third) carbon** atom **/**
OH (alcohol functional **group) not on C1 (C3)**
[CLASSIFY marks must be correct if JUSTIFY to be awarded marks.] (3 + 3 + 2)

(*b*) (*i*) IDENTIFY: **propanone /acetone / CH_3COCH_3 /** (3)



(*ii*) DRAW:



(3)

INDICATE: **OH** bond **//**
CH bond of **carbon to which OH is attached** (2 × 3)
[C-O formed unacceptable but cancellation not applied.]
[Hs attached to carbon atoms need not be shown explicitly but all CH bonds must be indicated and the H of OH **must** be shown]
[DRAW must be correct for INDICATE to be awarded marks.]

(*iii*) HOW: central carbon (carbon 2, C2, carbonyl carbon) changes from trigonal **planar to tetrahedral** and no other change (3)

(*c*) (*i*) WHAT: **addition / hydration** (3)

(*ii*) IDENTIFY: **propanol / propan-1-ol** (3)

(*d*) (*i*) WRITE: **$CH_3CH(OH)CH_3$ + Na $\rightarrow$ $CH_3CH(ONa)CH_3$ + ½H_2 / C_3H_7OH + Na $\rightarrow$ C_3H_7ONa + ½H_2 /**
$2CH_3CH(OH)CH_3$ + 2Na $\rightarrow$ $2CH_3CH(ONa)CH_3$ + H_2 /
$2C_3H_7OH$ + 2Na $\rightarrow$ $2C_3H_7ONa$ + H_2 FORMULAE: (3) BALANCING: (3)

(*ii*) WHAT: **acidic / loses proton** (3)

(*e*) (*i*) EXPRESS: **9.3** moles per litre (mol l^{-1}, M) (9)

70 cm^3 $CH_3CH(OH)CH_3$ per 100 cm^3	
$\Rightarrow$ **700** cm^3 $CH_3CH(OH)CH_3$ per litre	(3)
700 × 0.8 = **560** g $CH_3CH(OH)CH_3$ per litre	(3)
$\frac{560}{60^*}$ = **9.3**33 moles per litre (mol l^{-1}, M)	(3)

[**Addition must be shown for error to be treated as slip. Mr of 60.094 and subsequent work based on Ar values in Formula and Tables booklet acceptable.*]

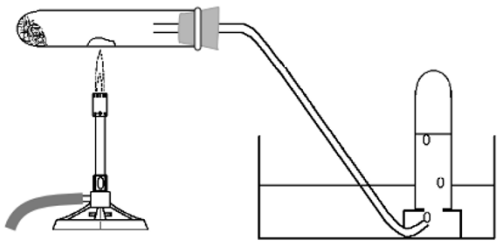
(*ii*) WHAT: **dipole-dipole** interactions **/ van der Waals** forces (3)

Question 4

(*a*) (*i*) GIVE: **ripening fruit / plant growth (regulator, inhibitor, promoter) /**
monomer for **polythene (polymer, plastic) manufacture /**
industrial **ethanol manufacture / manufacture antifreeze /**
precursor for **organic chemical synthesis** (4)

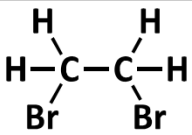
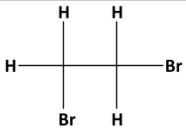
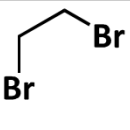
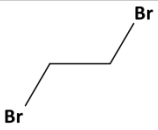
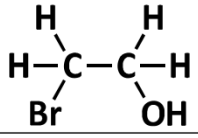
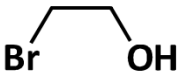
(*ii*) DRAW: **horizontal (slanting) test tube with** delivery **tube emerging** //
ethanol in **glass (steel, cotton) wool at end** //
heat source shown under catalyst (Al_2O_3) in **centre of test-tube** //
collection ethene (gas, bubbles) **over water** or in gas syringe **shown**

ANY THREE: (3 × 3)



[Diagram essential; at least one chemical or item of apparatus labelled]
[Unlabelled diagram (–3)]

(*iii*) DRAW:

				**CH_2BrCH_2Br / $BrCH_2CH_2Br$**
				**CH_2BrCH_2OH**

ANY ONE: (6)

[1,1-dibromoethane unacceptable and 1-bromoethanol unacceptable.]

(*iv*) EXPLAIN: ethene is **soluble in cyclohexane, insoluble in water //**

cyclohexane non-polar /
water polar /

no partial charges (dipoles) in ethene to interact with **partial charges (dipoles) in water) /**
ethene cannot disrupt **hydrogen bonding** of **water** molecules **/**
ethene cannot form hydrogen bonds with water /
ethene and cyclohexane have similar intermolecular forces (2 × 3)
['Like dissolves like' unacceptable.]

Question 5

a	b	c	d	e
9	**12**	**6**	**12**	**11**

(*a*) IDENTIFY: (*i*) **4** (3)

(*ii*) **1 / 3 / 5 / 6 / 8** (3)

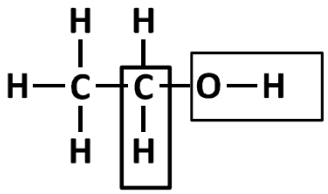
(*iii*) **2 / 7** (3)

(*b*) (*i*) WHAT: **hydrogen (H_2) //**
nickel (Ni) / platinum (Pt) / palladium (Pd) / copper (Cu) / rhodium (Rh) / ruthenium (Ru) (2 × 3)
[Accept any order of answering.]

or

$LiAlH_4$ / $NaBH_4$ (6)

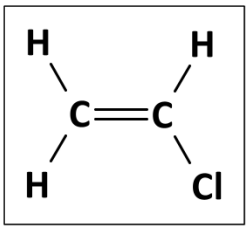
(*ii*) COPY etc: **OH** bond **//**
either **CH** bond of **carbon to which OH is attached** TWO BONDS: (2 × 3)
[Information only acceptable in diagram form.]



(*c*) IDENTIFY: **ethanol (C_2H_5OH, CH_3CH_2OH) / ethanal (CH_3CHO)** (3)

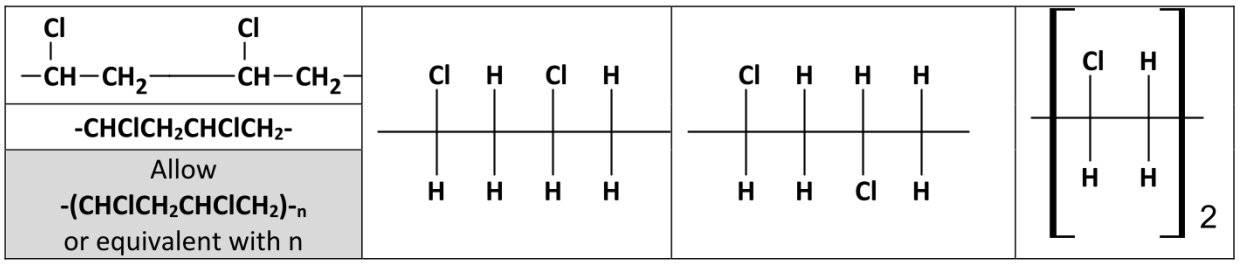
JUSTIFY: **hydrogen (H) bonding** with water (3)

(*d*) (*i*) IDENTIFY: **chloroethene** / 1-**chloroethene / 1-chloroethylene /** mono**chloroethene / CH_2CHCl / C_2H_3Cl / vinylchloride** (3)



(*ii*) HOW: **tetrahedral** to **//**
planar (2 × 3)
[correct order essential]

(*iii*) DRAW: (3)



$-CH(Cl)-CH_2-CH(Cl)-CH_2-$			
$-CHClCH_2CHClCH_2-$			
Allow **$-(CHClCH_2CHClCH_2)-_n$** or equivalent with n			

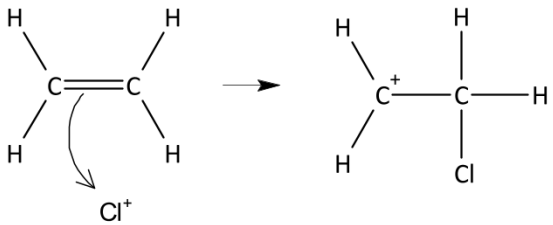
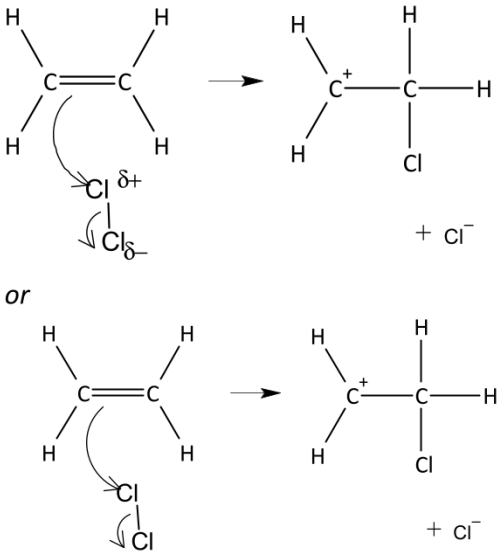
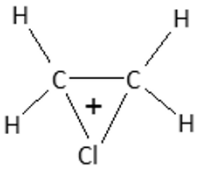
Correct carbon skeleton (4 carbons) with chlorines on alternate carbons
[End bonds need not be shown but terminal Hs not acceptable.]

(*e*) DESCRIBE: (3 + 3 + 3 + 2)

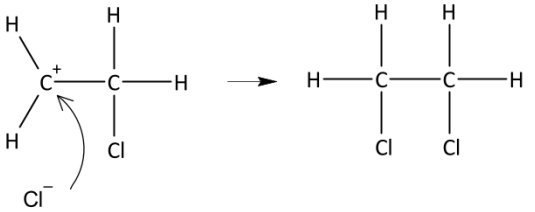
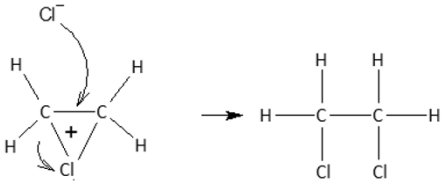
1. **chlorine (Cl_2) undergoes heterolytic fission / $Cl_2 \rightarrow Cl^+ + Cl^-$ / $Cl^{\delta+}—Cl^{\delta-} \rightarrow Cl^+ + Cl^-$**
or
chlorine (Cl_2) polarised approaching double bond / $Cl_2 \rightarrow Cl^{\delta+}—Cl^{\delta-}$ // (✓)
[bond (line) essential in $Cl^{\delta+}—Cl^{\delta-}$][bond (line) must not be shown between Cl^+ and Cl^-]

2. **attraction of Cl^+ to double bond / interaction of Cl^+ with double bond /**
or
attraction of positive end of $Cl^{\delta+}—Cl^{\delta-}$ (polarised Cl_2 molecule**) to double bond /**
positive end of $Cl^{\delta+}—Cl^{\delta-}$ (polarised Cl_2 molecule**) interacts with double bond**
or
breaking of double bond in ethene **and** polarised **bond in chlorine (Cl_2)** (✓)

3. **carbononium ion (carbocation, C^+, positively-charged intermediate,** bridged **chloronium ion) formed** (✓)

Left sides of equations = Second (✓) Right sides of equations = Third (✓)	[Hs need not be shown explicitly]
	 *or* Cl^- product need not be shown in these diagrams
 Accept bridged chloronium ion as product instead of carbonium ions above	

4. **addition of Cl^- to carbonium ion (carbocation, C^+, intermediate, bridged chloronium ion) gives product (1,2-dichloroethane)** (✓)

Either diagram for last (✓)	[Hs need not be shown explicitly]
	

Question 6

(*b*) (*i*) FIND: **CH_2O** (12)

$\frac{40.0}{12}$ = **3.33 / $^{10}/_{3}$** moles carbon [Allow 3.3] (3)

$\frac{6.67}{1}$ = **6.67 / $^{20}/_{3}$** moles hydrogen [Allow 6.7] (3)

$\frac{53.33}{16}$ **= 3.33 / $^{10}/_{3}$** moles oxygen [Allow 3.3] (3)

Dividing by smallest 1 : 2 : 1

$\Rightarrow$ **CH_2O** (3)

[Formula must be explicitly written, number ratio insufficient.]

(*ii*) WHAT: **$C_2H_4O_2$** (3)

(*iii*) GIVE: **ethanoic acid / CH_3COOH //**
methyl methanoate / $HCOOCH_3$ //
hydroxyethanal / $HOCH_2CHO$ ANY TWO: (2 × 3)

(*iv*) WHAT: **acid**ic group present **/ carboxylic group** present **/**
unknown is **ethanoic acid (CH_3COOH)** (4)

Question 7

(*a*) (*i*) WHAT: **two carbon (C) atoms attached to carbon (C) to which the OH (alcohol group, hydroxyl group) is attached** (5)

or

one hydrogen (H) attached to carbon (C) to which the OH (alcohol group, hydroxyl group) is attached (5)

[Do not allow hydroxide for hydroxyl and OH^- for –OH.]
[Allow 'OH group not attached to terminal (end) carbon (C) or OH group attached to middle carbon (C) of chain' for (4).]

(*ii*) PLOT: A: **correct numeric scales on both axes and one axis labelled (boiling point, °C)** (3)
[A marks not available if not on graph paper.]

B: **points correctly plotted** (6)
SIX POINTS: (6 × 1)
[Points need not be joined up.]
[Allow any lines or curves joining points.]

(*iii*) STATE: **increasing** (3)

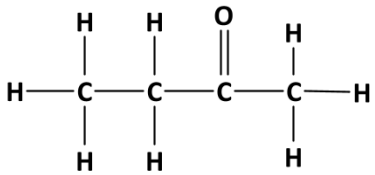
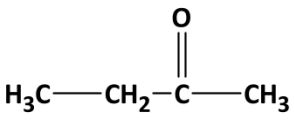
EXPLAIN: **more (stronger) intermolecular (van der Waals, dispersion, London) forces (bonds, interactions) / more (stronger)** temporary (induced) **dipoles / number of electrons increasing / electron cloud** that produces intermolecular forces **increasing** (3)
[Stronger (more) hydrogen bonds or stronger (more) permanent dipole-dipole unacceptable and cancellation applies. Reference to breaking covalent bonds unacceptable and cancellation applies.]

(*iv*) PREDICT: **105 – 130** °C (3)
[Method/reasoning need not be shown.]

(*b*) (*i*) GIVE: (6)

1-**butanal / butan**-1-**al //**
1-**butanoic acid / butan**-1-**oic acid**
TWO NAMES: (2 × 3)
[Numbering not essential but use of incorrect numbers unacceptable.]

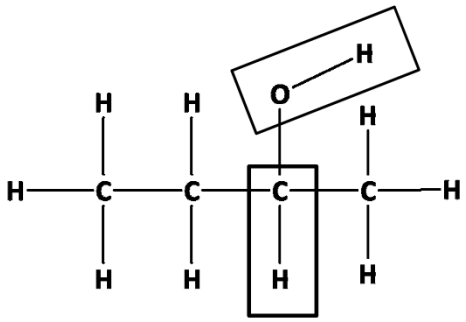
(*ii*) DRAW: (3)

 [Hs need not be explicitly shown.]		$CH_3CH_2COCH_3$

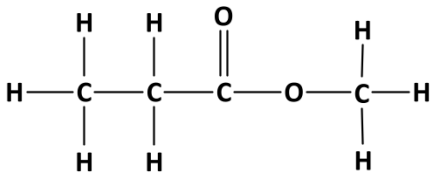
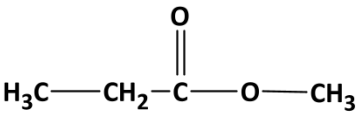
(*iii*) IDENTIFY: (6)

OH bond **//**
CH bond of **carbon to which OH (hydroxyl, alcohol group, functional group) is attached** /
CH bond **with OH (hydroxyl, functional group) attached to same C** /
CH bond of carbon (C) 2
TWO BONDS: (4 + 2)
[Information acceptable in diagram form.]

[Allow corresponding bonds in incorrect secondary alcohols.]



(*c*) (*i*) DRAW: (4)

 [Hs need not be explicitly shown.]		**$CH_3CH_2COOCH_3$**

(*ii*) HOW MANY: **3** (6)

[HOW MANY not linked to DRAW.]
[Award the mark in (*ii*) for the correct number of tetrahedral carbon atoms for an incorrect ester drawn at (*i*).]

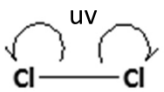
(*iii*) WHAT: (2)

methanol / CH_3OH //
sodium propanoate / sodium propionate / CH_3CH_2COONa / C_2H_5COONa
TWO PRODUCTS: (2 × 1)

Question 8

(*a*) A cross is unacceptable for a dot to indicate a free radical in (*i*), (*ii*), (*iii*) or (*iv*).

(*i*) EXPLAIN: **atom**s **(group**s **of atoms, molecule**s**, ion**s**, particles, species, substances** whose molecules**)** that **has (have) an unpaired electron / very reactive atom (group of atoms)** (✓)

(*ii*) HOW: **$Cl_2 \xrightarrow{UV} 2Cl^{\bullet}$ / Cl — Cl $\xrightarrow{UV}$ $2Cl^{\bullet}$ /**  **/**
chlorine molecule (bond) broken to give two chlorine free radicals / homolysis (homolytic fission) of Cl_2 by ultraviolet (uv) light (✓)
[uv not essential]

(*iii*) WHAT: **propagation** (✓)

WRITE: **$Cl^{\bullet} + CH_4 \rightarrow HCl + CH_3^{\bullet}$** (✓)

$CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ (✓)

[Any order for these two propagation steps acceptable.]

(*iv*) IDENTIFY: **ethane (C_2H_6, CH_3CH_3)** (✓)

EXPLAIN: **most methyl radicals ($CH_3^{\bullet}$) react with chlorine (Cl_2) /**
collisions (reaction) between methyl radicals ($CH_3^{\bullet}$) unlikely/
collisions (reaction) between methyl radicals ($CH_3^{\bullet}$) less likely than other collisions (reactions) /
probability of collisions (reaction) between methyl radicals ($CH_3^{\bullet}$) small /
concentration of methyl radical ($CH_3^{\bullet}$) small at all times **/**
collisions of methyl radicals ($CH_3^{\bullet}$) with chlorine (Cl_2) much **more likely /**
chlorine concentration much **greater than methyl radical ($CH_3^{\bullet}$) concentration /**
more chlorine (Cl_2) present than methyl radicals ($CH_3^{\bullet}$) (✓)

[IDENTIFY and EXPLAIN linked.]
[Allow propane, butane, etc only if their formation is fully and correctly justified.]

[Reference to chloride radical instead of chlorine unacceptable; **Cl^-** instead of **$Cl^{\bullet}$** unacceptable. Penalise (3) once each in (*ii*) and (*iii*) and (1) once (*iv*).]

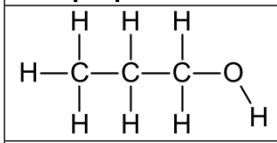
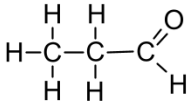
[Provided initiation described before propagation and propagation before termination, marks may be awarded for information provided without reference to numbering of parts (*ii*), (*iii*), (*iv*).]

Award 6 marks for each of the first two correct ticks, 3 marks for each of the next four correct ticks and one for the final correct tick. (6 + 6 + 3 + 3 + 3 + 3 + 1)

Question 9

QUESTION 8

(*a*) (*i*) DRAW: (2 × 3)

B	C
propan-1-ol	**propanal**
	
(3)	(3)

[ALL bonds, INCLUDING the bond between O and H in propan-1-ol, must be shown by separate strokes/lines.]
[Both alcohol and aldehyde functional group Hs MUST be explicitly shown.]

(*ii*) WHICH: **D / CH_3COOH/ ethanoic acid** (3)

(*b*) (*i*) EXPLAIN: *structural isomers:*
compounds with **same molecular formula (molecules with same set (group) of atoms, molecules with same number of same atoms)** and **//**
different arrangement of atoms / compounds that have **different structures (structural formulae)** (2 × 3)

primary alcohol:
one (one or no) carbon (C) atom **attached to carbon (C) to which the OH (functional group) is attached /**
one (one or no) carbon (C) atom **attached to hydroxyl carbon (C)** (6)

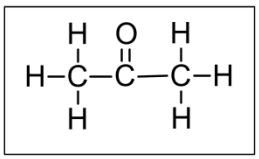
or

contains CH_2OH group / OH is attached to carbon (C) at the end of a chain /
OH is attached to terminal (primary, last, end, outer) carbon (C) (6)

or

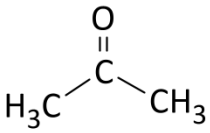
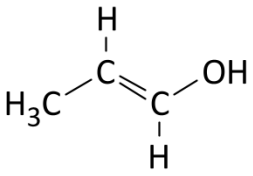
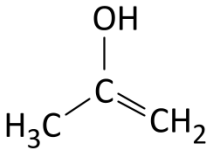
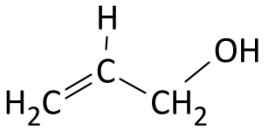
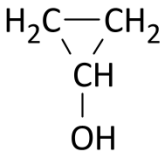
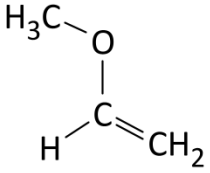
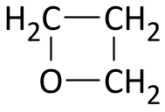
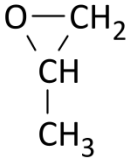
two (two or three) hydrogens (Hs) attached to carbon (C) to which the OH (functional group) is attached /
two (two or three) hydrogens (Hs) attached to hydroxyl carbon (C)
(6)

[Allow (6) for '*OH is at end of chain*'.]

(*ii*) DRAW: **CH_3COCH_3 / $(CH_3)_2CO$ /**  **/ correct structure of another isomer**
(3)

(*iii*) GIVE: **propan-2-one (propanone) /**
IUPAC name of drawn correct structural isomer of propanal (C_3H_6O) (3)
[DRAW and GIVE are linked.]

[Structural isomers of propanal are given on next page.]

Structural isomers of propanal		
Ketone	**CH_3COCH_3 /** 	**propan-2-one (propanone)**
Alcohols (and enols)	**$CH_3CH{=}CH(OH)$ /** 	**prop-1-en-1-ol / 1-propen-1-ol**
	$CH_3C(OH){=}CH_2$ / 	**prop-1-en-2-ol / 1-propen-2-ol**
	$CH_2{=}CHCH_2(OH)$ / 	**prop-2-en-1-ol / 2-propen-1-ol**
		**cyclopropanol**
Ethers		**methoxyethene**
		**oxetane**
		**2-methyloxirane /methyloxirane**

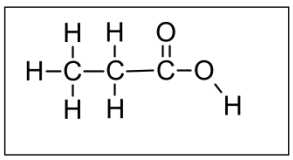
(*c*) EXPLAIN: (*i*) **propanal has dipole-dipole** forces (bonds, interactions) **/**
propanal is polar /
propanal has a polar CO (bond, group) //

butane has weaker **intermolecular forces (bonds, interactions) /**
butane has weaker **(van der Waals, London, dispersion)** forces **/**
butane is non-polar

(2 × 3)

(*ii*) ethanoic acid **has more (stronger) hydrogen (H) bonding** than propan-1-ol
[Allow '*ethanoic acid has **double H-bonding***'.] **/**
propan-1-**ol has less (weaker) hydrogen (H) bonding** than ethanoic acid **//**
an ethanoic acid molecule **has polar OH and CO bonds (polar OH and CO groups) /**
ethanoic acid **has two polar groups //**
ethanoic acid **forms dimers //**
a **propan**-1-**ol** molecule only **has a polar OH bond (a polar OH group) /**
propan-1-**ol has** only **one polar group** ANY TWO: (2 × 3)
[Marks may be awarded for information given in good diagrams.]

(*d*) WHAT: **propanoic (propionic) acid / CH_3CH_2COOH / C_2H_5COOH** (6)



(*e*) WRITE: **$C_3H_7OH + Na \rightarrow C_3H_7ONa + ½H_2$ / $2C_3H_7OH + 2Na \rightarrow 2C_3H_7ONa + H_2$ /**

$CH_3CH_2CH_2OH + Na \rightarrow CH_3CH_2CH_2ONa + ½H_2$ /
$2CH_3CH_2CH_2OH + 2Na \rightarrow 2CH_3CH_2CH_2ONa + H_2$

FORMULAE: (3) BALANCING: **(2)**

[Allow C_3H_8O for C_3H_7OH.]

Question 10

QUESTION 10

(*a*) DESCRIBE: **bubble (add, combine)** ethene into (with) **bromine water (solution) //**
red (brown, orange, yellow) bromine solution **decolorised** (2 × 3)

WOULD: **no** (3)

EXPLAIN: benzene is **stable (**quite **unreactive, aromatic) /** benzene **has no double bonds /**
benzene **bonds intermediate between double and single /**
benzene readily **undergoes substitution** (3)
[WOULD and EXPLAIN are linked.]

EXPLAIN: **shared between more than two atoms / shared by more than one bond**ed pair of atoms **/**
moving (not fixed) between one pair of bonded **atoms and another** (3)
[Allow '***shared by all six carbons*** *atoms'* and ***'moving around ring (hexagon)***
of carbon atoms'.][*Do not allow 'moving around whole molecule*'.]

HOW MANY: (*i*) **6** (3)

(*ii*) **12** (3)

WHAT: **carcinogen(ic) /** causes **cancer / mutagenic / breaks (damages) DNA (chromosomes) /**
toxic / harmful / dangerous **(4)**

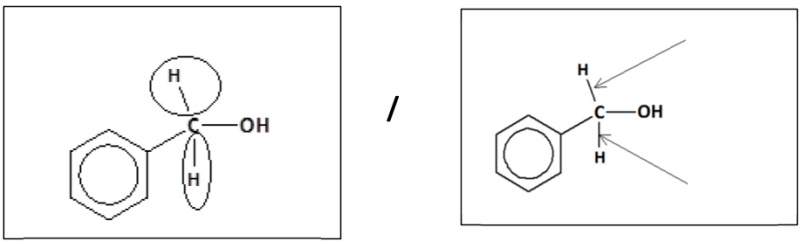
Question 11

QUESTION 8

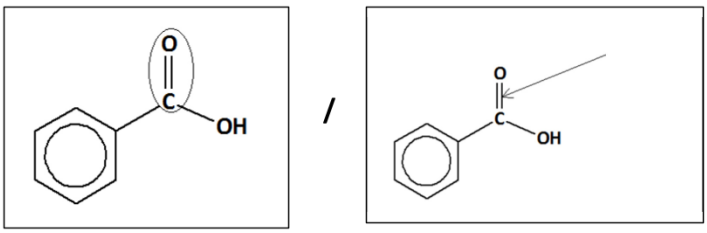
(*a*) WHAT: colourless to **purple (pink) to** brown to **colourless (white) /**
colourless to purple (pink) to **brown to colourless (white)** (3)

EXPLAIN: **MnO_4^- {Mn(VII)}** changes **to / MnO_2 {Mn(IV)}** changes **to** (3)
Mn^{2+} {Mn(II)} (3)
[Allow Mn^{7+} for Mn(VII) and Mn^{4+} for Mn(IV)]
[Oxidation of **MnO_4^- {Mn(VII), Mn^{7+}}** instead of reduction not acceptable.]
[WHAT and EXPLAIN linked]

MARK CLEARLY: (*i*) (3)

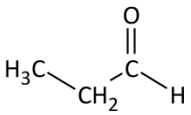
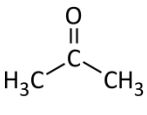
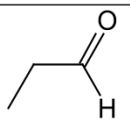
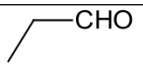
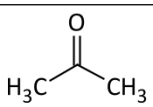


(*ii*) (3)



(*b*) GIVE: A = **propanal //**
B = **propanone** (2 × 3)
[Correct order essential unless substances clearly labelled A and B.]

DRAW: (2 × 3)

propanal	propanone
CH_3CH_2CHO	**CH_3COCH_3**
C_2H_5CHO	**$(CH_3)_2CO$**
	
	
	

[Aldehyde H must be explicitly shown, other Hs need not be explicit.]

(*c*) IDENTIFY: **hydrogen / H_2 //**
nickel (Ni, platinum, Pt, palladium, Pd, copper, Cu, rhodium, Rh, ruthenium, Ru) catalyst (2 × 3)

[Allow any order of response here.]

(*d*) SUGGEST: **Tollens'** reagent **/ ammoniacal silver nitrate / silver(I) oxide (Ag_2O) / Fehling's** reagent **/ Benedict's** reagent **/ copper(II) hydroxide {$Cu(OH)_2$}** (6)

(*e*) NAME: **methyl ethanoate / ethyl methanoate** (6)
[Full or condensed ester formula acceptable here. Molecular formula $C_3H_6O_2$ insufficient.]

IDENTIFY: (3 + 2)

NAME:	methyl ethanoate	ethyl methanoate	
IDENTIFY:	**methanol / CH_3OH** **ethanoic acid / CH_3COOH**	**ethanol / C_2H_5OH** **methanoic acid / HCOOH**	**(3 + 2)**

[NAME and IDENTIFY are linked and IDENTIFY marks only available where NAME marks awarded.]
[Alcohol and carboxylic acid may be identified by name, condensed formula or structure.]

Question 12

(*a*) NAME: **A = ethanol / ethyl alcohol //**
B = poly(ethene) / polyethene / polythene / polyethylene (2 × 3)

(*b*) IDENTIFY: **aluminium oxide / alumina / Al_2O_3 / concentrated sulfuric acid / H_2SO_4** (3)
WHAT: **elimination / dehydration** (3)
HOW: **tetrahedral to planar** (3)

(*c*) WHAT: **substitution** (3)

DESCRIBE: *initiation*:
homolysis (splitting, fission) of chlorine molecule (Cl_2) into
free **radicals (atoms, $Cl^\bullet$, Cl) by ultraviolet (uv) light** /
$Cl_2 \xrightarrow{uv} 2Cl^\bullet$ / $Cl_2 \xrightarrow{uv} 2Cl$ (3)

Where a candidate refers in name or in a drawing to methane instead of ethane and/or methyl instead of ethyl and/or ethane instead of butane, deduct 3 marks but only once in (*c*).

propagation (*1*):
chlorine radical (atom, $Cl^\bullet$, Cl) reacts with ethane molecule (C_2H_6) giving hydrogen chloride (HCl) and an ethyl radical ($C_2H_5^\bullet$) /
$Cl^\bullet + C_2H_6 \rightarrow HCl + C_2H_5^\bullet$ / $Cl + C_2H_6 \rightarrow HCl + C_2H_5^\bullet$ (3)
[Hydrochloric acid **not** acceptable for HCl and cancellation applies.]
[Where C_2H_5 used instead of $C_2H_5^\bullet$ deduct 3 marks but only once in (*c*).]

propagation (*2*):
ethyl radical ($C_2H_5^\bullet$) reacts with chlorine molecule (Cl_2) giving mono**chloroethane (C_2H_5Cl) and a chlorine radical (atom, $Cl^\bullet$, Cl) /**
$C_2H_5^\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl^\bullet$ / $C_2H_5^\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl$ (3)

Where a radical is referred to as an ion or where a diagram shows a radical but the description refers to an ion cancellation applies *each* time.

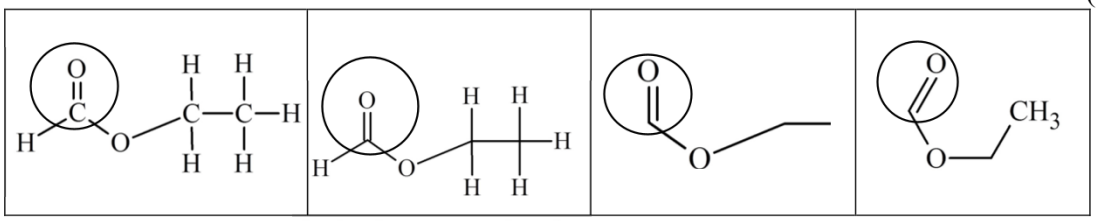
chain reaction occurs / **propagation steps repeat until one reactant used up /**
propagation steps repeat until termination reached (3)
[Accept 'chain reaction occurs' anywhere in (*c*).]

termination:
combination of remaining **radicals to form molecules (chlorine, chloroethane, butane) /**
$2Cl^\bullet \rightarrow Cl_2$ / $2Cl \rightarrow Cl_2$ /
$Cl^\bullet + C_2H_5^\bullet \rightarrow C_2H_5Cl$ / $Cl + C_2H_5^\bullet \rightarrow C_2H_5Cl$ /
$2C_2H_5^\bullet \rightarrow C_4H_{10}$ (3)

EXPLAIN: tetraethyllead **increases the rate** (**speeds up** reaction) by **providing (producing, breaking into)** ethyl free **radicals** /
tetraethyllead increases **initiates (promotes)** reaction by **providing (producing, breaking into)** ethyl free **radicals** (3)
['Radical promoter' insufficient on its own.]

(*d*) NAME: **ethyl methanoate / ethyl formate** (3)

DRAW: (6)



Note some or all of the hydrogens and carbons need not be shown explicitly; -C_2H_5 need not be expanded; allow -Et instead of -C_2H_5; accept $HCOOC_2H_5$] [NAME and DRAW not linked.]

CIRCLE: ***only the carbonyl group circled*** (3)

[Allow carbonyl identified in incorrect **ester**.]

WHAT: base **hydrolysis** / **saponification** **(2)**

Question 13

QUESTION 8

(*a*) GIVE: **A = propene / prop-1-ene**
B = 2-propanol / propan-2-ol
C = propanone / propan-2-one

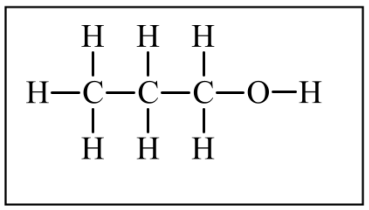
(3 + 3 + **2**)

(*b*) NAME: **poly(propene) / polypropylene** [*'Polypropene'* is acceptable.] (3)

(*c*) IDENTIFY: *broken:* **C to O pi (π)** bond / **(pi (π)** bond of **CO (carbonyl)** //
formed: **OH / O–H / O to H** //
formed: **CH / C–H / C to H** (3 × 3)
[C to O, (CO, carbonyl, double, C=O) as bond broken is acceptable.][H_2 (H-H) broken unacceptable but does not cancel.]
[C to O, (C-O, C to OH, C-OH, COH) as a bond formed is acceptable.]
[Information given *clearly* in diagram form is acceptable.]

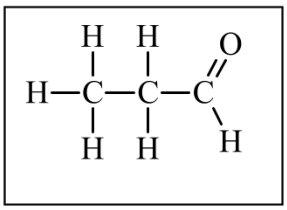
(*d*) NAME: *isomer*: **1-propanol / propan-1-ol / propyl alcohol** //
aldehyde: **propanal / propionaldehyde** (2 × 3)

DRAW: *isomer*:



//

aldehyde:



(2 × 3)
[*Where the order in the question (isomer-aldehyde) is not followed, the identities of the compounds must be clearly indicated.*][*-OH, -HO* for *O-H* acceptable.]

HOW: with **hydrogen (H_2)** and **nickel (Ni, platinum, Pt, palladium, Pd, ruthenium, Ru)** catalyst / **lithium aluminium hydride (lithium tetrahydroaluminate, $LiAlH_4$) / sodium borohydride (sodium tetrahydroborate, $NaBH_4$)** (6)
['*Reduction*' or '*hydrogenation*' acceptable for (3).]

(*e*) IDENTIFY **A (C_3H_6, propene) = – 48 °C (lowest** boiling point) //

B ($CH_3CHOHCH_3$, propan-2-ol, 2-propanol) = 82 °C (highest boiling point) //

C (CH_3COCH_3, propanone) = 56 °C (middle boiling point) ANY TWO: (2 × 3)

JUSTIFY: **A (C_3H_6, propene) has van der Waals (London, dispersion, weakest dipole-dipole, temporary, transient) forces (attractions, bonds)** between the molecules //
B ($CH_3CHOHCH_3$, propan-2-ol, 2-propanol) has hydrogen (strongest dipole-dipole) bonds (forces, attractions) between the molecules //
C (CH_3COCH_3, propanone) has dipole-dipole forces (attractions, bonds) between the molecules

CORRESPONDING TWO: (2 × 3)
[*The marks for* JUSTIFY *may be awarded if the answers are clearly linked with the* ***compounds*** *given for* IDENTIFY.]
[*If* JUSTIFY *is given in terms of weak or strong or medium strength intermolecular forces that are not named* (3) *may be awarded.*]

Question 14

(*a*) DISTNG: saturated hydrocarbons contain **all (only) single (no double** or triple**)** carbon-carbon **bonds / saturated** hydrocarbons **have maximum number of hydrogen (monovalent) atoms attached** to carbon skeleton //
unsaturated hydrocarbons contain at least one **double (triple, multiple)** carbon-carbon **bond / more hydrogen (monovalent) atoms can be added** to carbon skeleton of **unsaturated** hydrocarbons **(2 × 2)**
[*Where the order in the question is not followed, the part of the answer referring to saturation and the part referring to unsaturation must be clear.*]

DESCRIBE: **bromine (Br_2)** solution (water) /
acidified potassium **manganate(VII) (permanganate) / ($KMnO_4/H^+$) / (MnO_4^-/H^+)** (6)

decolourises (changes to colourless, colour disappears) (3)
['*Clear*' unacceptable for '*colourless*'.]

HOW MANY: **6** (3)

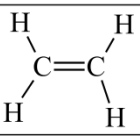
EXPLAIN: (*i*) yes, each of the **3 double bonds** has 2 pi-electrons / **each carbon has** 3 sigma and **one pi electron)** (3)
(*ii*) **electrons** in benzene are **delocalised / electrons are in three double bonds** in the Kekulé structure /
electrons localised in the Kekulé structure (3)

GIVE: all **carbon-carbon (C-C) bonds** in benzene **are of same length (energy, strength) /** all **carbon-carbon (C-C) bonds** in benzene **are intermediate between single and double in length (energy, strength) /** chemical **stability (unreactivity)** of benzene / **no isomers of 1,2-disubstituted benzene / reacts** mainly **by substitution / does not decolourise Br_2** solution easily / **does not decolourise acidified $KMnO_4$** solution easily / **does not undergo** electrophilic **addition** (3)

Question 15

(*a*) GIVE: **ethene**

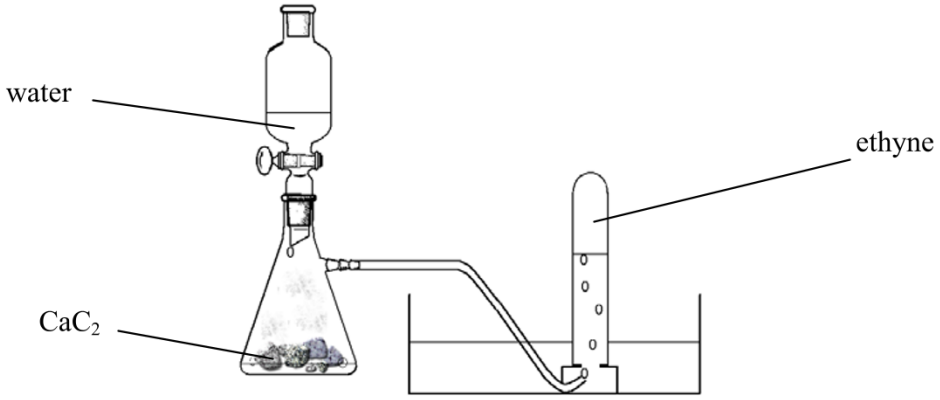
DRAW:

$CH_2=CH_2$	**$H_2C=CH_2$**	

[*In the fully-expanded structure the* **H***s may be omitted.*]

(3 + 2)

(*b*) DRAW:



water dropping on to / tap (dropping) funnel containing **water** //

calcium(II) di**carbide (CaC_2)** //

delivery tubing shown //

collection of ethyne (C_2H_2 or A) over water in test-tube, gas jar, etc
[Water in collection trough must be shown but need not be labelled.]
[Max 6 if no diagram.] [Ignore purification of ethyne if included.]

(4 × 3)

(*c*) DESCRIBE: **correct reagent {bromine (Br_2)** solution /
acidified potassium **manganate(VII) (permanganate) ($KMnO_4/H^+$) (MnO_4^-/H^+)**} //

initial colour of bromine {brown (red, orange, yellow) /
initial colour of acidified manganate(VII) {purple (pink)} //

colourless (decolorises, colour disappears) in case of B (**ethene, C_2H_4**) distinguishes B from C
[The reagent and colour change must correspond.][‘Clear’ unacceptable for ‘colourless’]

(3 × 3)

(*d*) (*i*) NAME: **free radical substitution** (3)

(*ii*) GIVE: *initiation*:
homolysis (splitting, fission) of chlorine molecule (Cl_2) into free **radicals (atoms, $Cl^\bullet$) by ultraviolet (uv) light** / $Cl_2 \xrightarrow{uv} 2Cl^\bullet$ / $Cl_2 \xrightarrow{uv} 2Cl$ (3)

Where a candidate refers in name or in a drawing to methane instead of ethane and/or methyl instead of ethyl and/or ethane instead of butane, deduct 3 marks but only once in (*d*).

propagation (*1*):
chlorine radical (atom, $Cl^\bullet$, Cl) reacts with ethane molecule (C_2H_6) giving hydrogen chloride (HCl) and an ethyl radical ($C_2H_5^\bullet$) /
$Cl^\bullet + C_2H_6 \rightarrow HCl + C_2H_5^\bullet$ / $Cl + C_2H_6 \rightarrow HCl + C_2H_5^\bullet$ (3)
[Hydrochloric acid **not** acceptable for HCl and cancellation applies.]
[Where C_2H_5 used instead of $C_2H_5^\bullet$ deduct 3 marks but only once in (*d*).]

propagation (*2*):
ethyl radical ($C_2H_5^\bullet$) reacts with chlorine molecule (Cl_2) giving mono**chloroethane (C_2H_5Cl) and a chlorine radical (atom, $Cl^\bullet$, Cl) /**
$C_2H_5^\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl^\bullet$ / $C_2H_5^\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl$ (3)

Where a radical is referred to as an ion or where a diagram shows a radical but the description refers to an ion cancellation applies *each* time.

chain reaction occurs / **propagation steps repeat until one reactant used up** (3)
[Accept 'chain reaction occurs' anywhere in (*d*).]

termination:
combination of remaining **radicals to form molecules (chlorine, chloroethane, butane) /**
$2Cl^\bullet \rightarrow Cl_2$ / $2Cl \rightarrow Cl_2$ /
$Cl^\bullet + C_2H_5^\bullet \rightarrow C_2H_5Cl$ / $Cl + C_2H_5^\bullet \rightarrow C_2H_5Cl$ /
$2C_2H_5^\bullet \rightarrow C_4H_{10}$ (3)

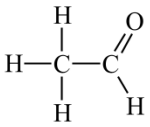
(*iii*) EXPLAIN: traces of **butane (C_4H_{10})** occur as consequence of **$C_2H_5^\bullet$ (ethyl radicals) combining** (6)

[**N.B.** The marks in part (iii) may only be given for answers in part (iii) and not for similar answers in part (ii). If the parts are not numbered, appropriate answers in part (ii) must be repeated if the marks available for part (iii) are to be awarded.]

Question 16

(*a*) (*i*) GIVE: production of **cellulose acetate** / production of **vinyl acetate (VAM)** / production of **polyvinyl acetate** / production of **acetic anhydride (acetylating agent)** / **solvent** / **vinegar** / **flavouring** / **preserving** **(4)**

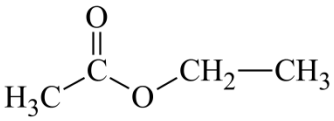
(*ii*) DRAW:



(2×3)

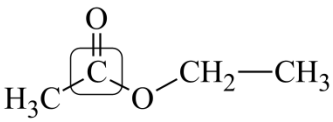
[Allow 3 for methyl even if not expanded. If fuly expanded the **H**s of the methyl group need not be shown.][Allow 3 for aldehyde group with all bonds shown.]

(*iii*) DRAW:

$CH_3COOC_2H_5$	

[In the fully-expanded form the **H**s need not be shown.]

(6)

IDENTIFY: **carbonyl carbon /**  [May be indicated by arrow, colouring, asterisk, etc.] (3)

[Accept correct planar carbon in an incorrect structure.]

(*iv*) HOW: **hydrogen (H_2) / hydrogenation //**
nickel (Ni) {platinum (Pt), palladium (Pd) or ruthenium (Ru)}

(2 × 3)

or

lithium aluminium hydride (lithium tetrahydroaluminate, $LiAlH_4$) /
sodium borohydride (sodium tetrahydroborate, $NaBH_4$) (6)

Question 17

(a) EXPLAIN: **general formula // differ by CH_2 // same functional group // similar chemical properties // gradation in physical properties // similar method of preparation**
[Accept "uniform chemical type" for "similar chemical properties".] ANY ONE: (6)

WHAT: **addition / hydrogenation / reduction** (3)

HOW: **planar (from 120° bond angle*) //** to **tetrahedral* (to 109° 28' / 109.5°)**
*[*For the tetrahedral angle, accept* 109 – 109.5°*]* (2 × 3)

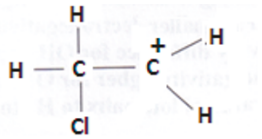
[If explained in terms of bond angles the numbers alone are not sufficient but the words "bond angle" are only required once.]

(b) IDENTIFY: *(i)* **chlorine (Cl_2)** // *[Do not accept Cl.]*

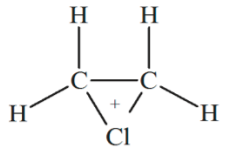
(ii) **hydrogen chloride (HCl)** //

(iii) **chlorine (Cl_2)** *[Do not accept Cl.]* (3 × 3)

(c) DESCRIBE: **polarisation of chlorine** molecule by double bond / **($Cl^{\delta+}$–*$Cl^{\delta-}$)** // *[*Line essential]*
followed by **heterolytic fission of chlorine** molecule **(Cl_2)** / $Cl_2 \rightarrow$ **Cl^+ +*Cl^-** /
[Bond must not be shown.]*
addition (attraction, bonding) of Cl^+ ($Cl^{\delta+}$ – $Cl^{\delta-}$) to the double bond //
[Do not accept addition of $Cl^{\delta+}$; on a diagram $Cl^{\delta+}$ – $Cl^{\delta-}$ must be oriented correctly.]
forming a localised **carbonium ion* (carbocation*)** *[*Accept positive carbon (C^+).]*
(chloronium ion) /



/

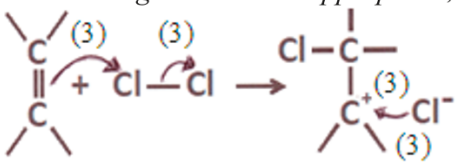


//

addition of chloride ion (Cl^-) to the intermediate (named intermediate) to give
1,2-dichloroethane ANY FOUR: (4 × 3)

[In each step, an incorrect point cancels a correct point e.g. one incorrect, one correct (0), one incorrect, two correct (3), two incorrect, two correct (0).]

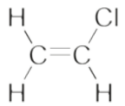
[Points may be got from suitable diagrams. Where appropriate, allow correct use of curly arrows, e.g



]

[If addition of HCl is described, award (3) for carbonium ion (not chloronium ion – but do not cancel). Award (3) for addition of chloride ion to carbonium ion.]

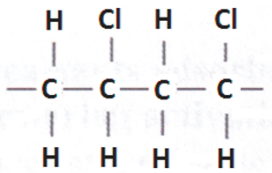
(d) DRAW: **$CH_2 = CHCl$** /



(6)

NAME: 1-**chloroethene / chloroethylene / monochloroethene / monochloroethylene / vinyl chloride** (3)

(e) DRAW:



/ **– CH_2 – CHCl – CH_2 – CHCl –** (5)

[Accept if formula in brackets with subscript n outside.]

[End bonds not required.]

Question 18

QUESTION 8

(a) GIVE: *(i)* **propan-2-ol / 2-propanol** (5)

[Allow 3 marks for 'propanol']

(ii) **propyl methanoate** (3)

(b) EXPLAIN: compounds with the **same molecular formula //**

but having **different structures (different structural formulas) / arranged differently in space** (2 × 3)

WHAT: *primary*: **RCH_2OH / contains CH_2OH / one carbon attached to OH carbon /** at least **two Hs attached to OH carbon / OH on end carbon //**

secondary: R**CHOH**R^1 **/ contains CHOH / two carbons attached to OH carbon / only one hydrogen attached to OH carbon** (2 × 3)

IDENTIFY: **propanal** and **propanone** (6)

(c) CPD: **A / alcohol A / propan-2-ol / propan-1-ol** (3)

[Allow 'propanol']

(d) NAME: *reagent*: **hydrogen //**

catalyst: **nickel / palladium / platinum** (2 × 3)

[Accept lithium aluminium hydride and sodium borohydride for 3 only. Accept formulas.]

(e) DESC: **mix (add)** equal amounts of **Fehling's A (1) and Fehling's B (2)** in a test tube //

add a small amount of **propanal //**

heat / warm / place in water bath (may be got from a diagram) //

note any **change / red precipitate (ppt)** formed / **copper(I) oxide (Cu_2O)** formed / **blue colour changes**

ANY THREE: (3 × 3)

WHY: propanone **not easily oxidised / not oxidised by Fehling's reagent / poor reducing agent /** **Fehling's reagent a** very **weak oxidising agent** (too **weak an oxidising agent)** (3)

(f) WHICH: **B / ester / ester B / propyl methanoate / $HCOOC_3H_7$** (3)

[Accept the ester given as answer in (a) (ii) even if incorrect.]

Question 19

QUESTION 10

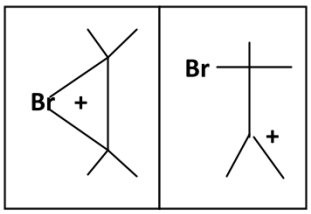
(a) *(i)* presence of **double bond (unsaturation)** //

which is **electron rich** / which can **donate electrons** / which is a **nucleophile** /
pi bond weak (pi bond more **easily broken) / high electron density** (4 + 3)

(ii) MECHANISM:

polarisation of Br_2 / $Br^{\delta+}$ – $Br^{\delta-}$ under influence of double bond //

followed by **heterolytic fission / splitting into ions / Br^+**&(+) **Br^-** //



addition of bromonium ion (Br^+) across (to) the double bond /
addition of Br^+ forming bridged intermediate (cyclic bromonium ion)
*[Obtainable from correct diagram. Accept localised **carbonium ion**.*
Also accept cyclic bromonium ion with poitive charge on the Br] //

attack (addition) of bromide ion (Br^-) to bridged intermediate /
attack (addition) of bromide ion (Br^-) to cyclic Br^+ /
attack (addition) of bromide ion (Br^-) to carbonium ion (C^+) (4 × 3)
[The information in this point may also be got from a suitable diagram (equation).]

STATE: **when named nucleophiles (anions, negative ions) present (alternative nucleophile source {e.g. Cl^- or NaCl (HCl); OH^- or H_2O}) and an identified matched product** (6)
[May be got from example e.g. 2-bromoethanol if (bromine) water is present. Structural formulas accepted.]

Question 20

QUESTION 8

(a) DESC: *initiation*: **homolysis (splitting) of chlorine molecule (Cl_2) into free radicals ($Cl^{\bullet}$) by ultraviolet (uv)** light / $Cl_2 \xrightarrow{uv} 2Cl^{\bullet}$ //

propagation: **reaction of chlorine radical ($Cl^{\bullet}$) with methane molecule (CH_4) to give hydrogen chloride (HCl) and a methyl radical ($CH_3^{\bullet}$) /**
$Cl^{\bullet} + CH_4 \rightarrow HCl + CH_3^{\bullet}$ //
reaction of methyl radical ($CH_3^{\bullet}$) with a chlorine molecule (Cl_2) to give mono**chloromethane (CH_3Cl) and a chlorine radical ($Cl^{\bullet}$) /**
$CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ //

chain reaction occurs //

termination: **combination of** remaining **radicals to form molecules /**
$Cl^{\bullet} + CH_3^{\bullet} \rightarrow CH_3Cl$ /
$2Cl^{\bullet} \rightarrow Cl_2$ /
$CH_3^{\bullet} + CH_3^{\bullet} \rightarrow C_2H_6$ ANY FOUR: (4 × 3)

STATE: **three × [piece of evidence // corresponding explanation]** 3 × (2 × 3)

PIECE OF EVIDENCE	**CORRESPONDING EXPLANATION***
promoted **by uv** at room temp	**effect of uv suggests free radical mech. / photons (uv, hυ) split Cl_2 / energy unable to split C – H /** accept **does not take place in the dark** at room temp.
for every photon absorbed many chloromethane molecules formed	**evidence for chain reaction or propagation**
ethane formed	**shows $CH_3^{\bullet}$ present /** $2CH_3^{\bullet} \rightarrow C_2H_6$ [*not given from termination above*]
add source of free radicals {tetra-methyl (tetraethyl) lead}	**only free radical mech. would be affected / increased rate / ionic addition unaffected / free radicals promote chain reaction**
inhibitors (e.g. oxygen) slow reaction	inhibition **sure indicator of chain reaction / inhibitor (O_2) combines with radicals ($CH_3^{\bullet}$) / inhibitor (O_2) stops chain** formation
no H_2 produced	**no $H^{\bullet}$ formed / C – H not split** by uv
HCl produced	**shows $Cl^{\bullet}$ produced / proves $Cl^{\bullet}$ attacks CH_4**

**Piece of evidence and explanation must be matched*

(b) (i) NAME: **elimination** [*Accept 'dehydration.'*] (3)

(ii) BROKEN: **C – H and C – O**
FORMED: **C = C and O – H / C to C π (pi) bond and O – H** (6 + 3)

(c) DESCRIBE: six identical **carbon-to-carbon sigma (single) bonds** //
sigma (single) bonds from carbon to hydrogen //
delocalised π (pi) electron(s) (bonds, cloud) / formed from six p orbitals (electrons) [*Accept correct description*] (3 + 3 + 2)
or
identical carbon-to-carbon bonds //
intermediate in length **between single and double / resonance str (hybrid)** //
delocalised π (pi) electron(s) (bonds, cloud) / formed from six p orbitals (electrons) / six delocalised electrons (3 + 3 + 2)

Question 21

QUESTION 9

(a) NAME: **Ethene / ethylene** (5)
[Allow (3) for C_2H_4]

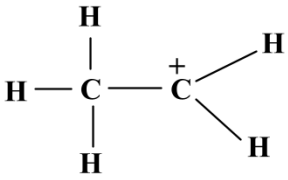
(b) IDENTIFY: (i): **Y / V** [Accept W] //

(ii): **Z** (2 × 3)

(c) DESCRIBE: **Heterolytic fission** of hydrogen chloride molecule / **HCl → Cl^- + H^+** //

Addition (attraction, bonding) of H^+ ($H^{\delta+}$– $Cl^{\delta-}$) to the double bond //

Forming a localised **carbonium* ion (carbocation*)** / *Accept positive carbon (C^+)



//

Addition of Cl^- to the carbonium ion (C^+) to give chloroethane (4 × 3)
[Note: Where appropriate, allow correct use of 'curly' arrows.]

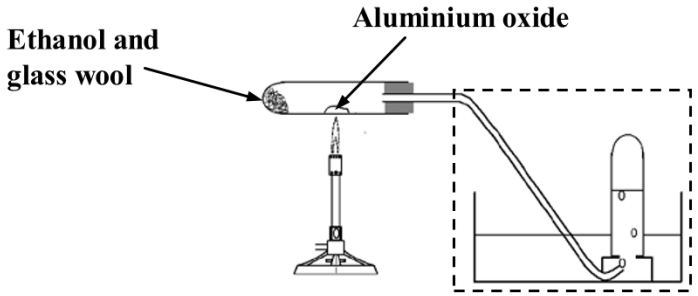
(d) STATE: (i): **H_2** Accept H_2 & condition reversed e.g. Ni/H_2. (6)
If reagent omitted (or incorrect), give (3) if a correct condition {Ni, Pd, Pt, heat (140°)} is given.

(ii): **Cl_2 // h*f* (hν) / ultraviolet (uv)** light / **sunlight / heat** (2 × 3)

(e) DRAW: **Apparatus correctly drawn //**

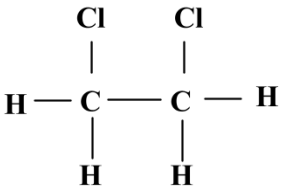
Ethanol held in glass wool (in labelling) //

Aluminium oxide correctly placed and heated (in labelling) (3 × 3)



[Note: The collection part of the diagram (the part in the box) is not required.]

(f)



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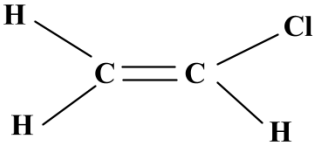


(2 × 3)

[Allow **CH_2ClCH_2Cl** and **CH_2=CHCl**]

Question 22

QUESTION 8

(a) GIVE: **A = ethanol** (3)
B = ethanal (3)
C = ethanoic acid (3)
D = ethyl ethanoate (3)

[If not designated A, B, C, D, the order in the question should be followed. If only one name is given, and it is undesignated, assume it is the first.]

(b) NAME: saturated, aliphatic **aldehydes** / **alkanals**

COMPOUND: **benzaldehyde / benzenecarbaldehyde / benzenecarboxaldehyde / benzoic aldehyde / phenylmethanal / oil of bitter almonds** (6 +3)
[Name required]

(c) WHICH: **A / ethanol / ethyl alcohol** (3)

OTHER: **B / ethanal / acetaldehyde** (3)

(d) DESCRIBE: **effervescence / fizzing / bubbling / gas (CO_2) produced (evolved, given off) /** sodium **carbonate (solid, powder) dissolves / clear solution formed** (3)

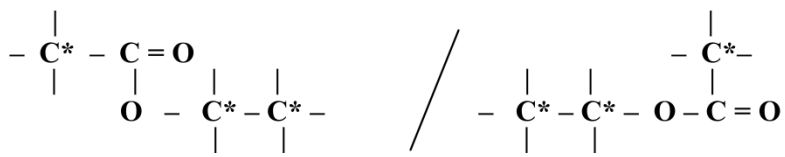
WRITE: **$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$ [or H_2CO_3]**
FORMULAS: (3) BALANCING: (3)

NAME: **vinegar** (3)

EXPRESS: **6** % (w/v) (3)

60* ÷ 10 = 6 (3)
**addition must be shown for error to be treated as slip.*

(e) DRAW: (5)



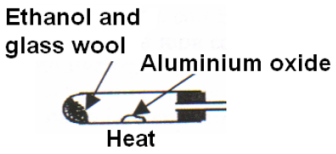
[Accept "CH_3" for methyl group and "CH_2CH_3 for ethyl group; if "C_2H_5" used for ethyl group, give 3 only.]

LABEL: **all three tetrahedral carbon atoms clearly labelled or identified** (3)

*[*DRAW & LABEL*: These are linked. The (3) marks for the three tetrahedral carbons required in* LABEL *may only be awarded when the formula of ethyl ethanoate in* DRAW *is correct.]*

Question 23

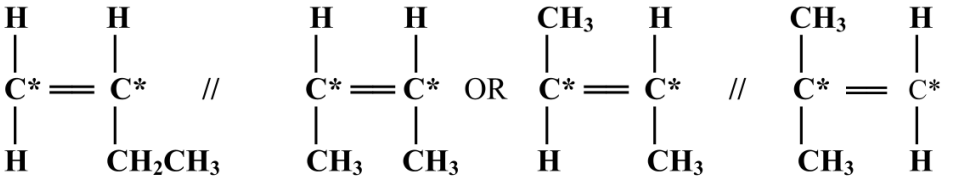
(a) DRAW:



ethanol (C_2H_5OH) and glass wool (4)
aluminium oxide (Al_2O_3) and heat (correctly positioned) (4)

[No diagram: (–3) but do not go below 0.]

(b) ISOMER:



(6)

$CH_2=CHCH_2CH_3$ $CH_3CH=CHCH_3$ $(CH_3)_2C=CH_2$

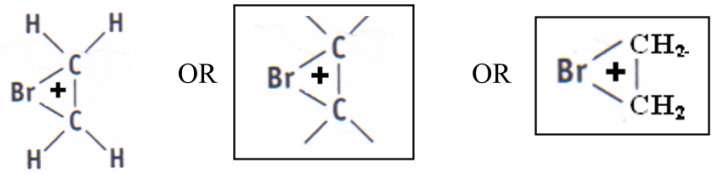
[Note: CH_3 and CH_2CH_3 may be expanded. CH_2CH_3 may be written C_2H_5. In CH_2CH_3, the C of CH_3 must not be bonded to a planar C (C). Single Hs may be omitted in expanded structures.]*

[Cancelling to be applied]

INDICATE: *planar*: **one C (C* in diagrams) at end of double bond** (clearly labelled or stated)** (3)
tetrahedral: **one C other than at end of double bond** (clearly labelled or stated)** (3)
Note: If C_3 alkene presented, allow the marks for indicating planar and tetrahedral carbons.
***Cancelling applies.*

(c) EXPLAIN: **having** at least **one multiple (double, triple)** carbon-to-carbon **bond / undergoes addition reactions** (6)

(d) DRAW:



(6)

[+ may be on Br]

[Accept corresponding localised carbonium ion,  *]*

GIVE: **three correct products (name or formula)** (3 x 3)

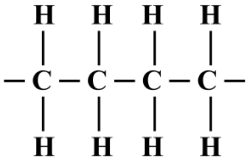
Name	Formula
1,2-dibromoethane	CH_2BrCH_2Br
2-bromoethanol	CH_2BrCH_2OH
1-bromo-2-chloroethane*	CH_2BrCH_2Cl

[accept 1-chloro-2-bromoethane, NaOH, NaBr.]*
[Accept dibromoethane if correct formula for 1,2-dibromoethane is given.] *[Cancelling applies]*

HOW: **different negative ions {anions, two of Br^-, OH^-, Cl^-,** also **water (H_2O)}** adding on **indicates (supports, shows, proves) presence of positive** intermediate **/ these products indicate the formation of a positive ion first and then the addition of different negative ions (nucleophiles, anions) to it** *[Can be shown by drawings] [HOW must be specifically related to organic products]* (3)

(e) NAME: **poly(ethene) / polythene** *[accept polyethene]* (3)

DRAW:



/ $-CH_2-CH_2-CH_2-CH_2-$ *[The end bonds may be omitted]* (3)

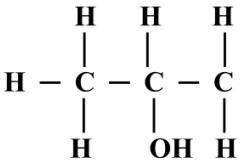
[The Hs may be omitted in the fully expanded structure]

Question 24

(a) (i) CATALYST: **nickel / palladium / platinum / copper** *[Accept symbol]* (4)

(ii) ALCOHOL: **propan-1-ol / 1-propanol / *n*-propyl alcohol** (3)
[Accept structural formula] [Not "propanol" unless correct structure shown, but does not cancel.]

(iii) DRAW:



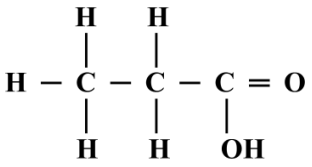
/ **$CH_3CHOHCH_3$** / **$(CH_3)_2CHOH$** (3)
[OH may be bracketed in condensed structures]

CLASS: **secondary** (3)

(iv) WHICH: **propanal** *[Accept structure]* (3)

NAME: **propanoic acid / propionic acid** / sod. **propanoate** / sod. **propionate** (3)

STRUCTURE:



/ **CH_3CH_2COOH** / **C_2H_5COOH** (3)
(**O^-** or **ONa** instead of **OH** for salts)

(v) USE: **removing nail varnish / cleaning glassware / solvent / chromatography / recrystallisation / dry cleaning / stain removing / grease removing** *[Do not accept "fuel".]* (3)

Question 25

(a) NAME: (i) **alkenes (olefins)** (4)
(ii) **aldehydes (alkanals)** (4)

(b) WHAT: **loss of (removal of) small molecule (water, hydrogen chloride, H_2O, HCl)** (3)
[Accept "dehydration"]

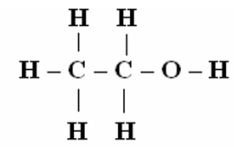
change to (formation of) unsaturated compound **(double bond, planar carbon / planar geometry)** (3)
[Note: equation not sufficient on its own; the features must be stated.]

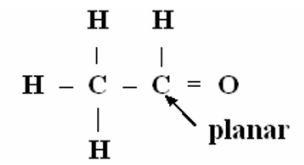
(c) REAGENT: **hydrogen** [Accept: 'hydrogenation'] (3)
[Reagent-catalyst order not required]
CATALYST: **nickel (Ni) / palladium (Pd) / platinum (Pt)** (3)

[Accept: **lithium aluminium hydride ($LiAlH_4$, lithium tetrahydroaluminate) / sodium borohydride ($NaBH_4$, sodium tetrahydroborate)** for 6 marks]

(d) DRAW: **B** // **C** (2 x 3)

[Accept OH]





INDICATE: **correct indication of planar carbon atom** (3)

LIST: *bonds broken in B*: **C – H** // **O – H** (2 x 3)

bond made in C: **C = O** [Accept "carbon (C) to oxygen (O) bond"] (3)
[cancelling applies]

(e) HOW: **heat / warm / boil** // with **specified reagent** // **observation** (3 x 3)

reagent	observation
Fehling's solution	red (orange, etc.) ppt.
Tollens' reagent (ammoniacal silver nitrate, ammoniacal silver oxide, ammoniacal silver ions)	silver
2,4-dinitrophenylhydrazine (6 marks)	orange (red, yellow) ppt.

["silver mirror test" on its own gets (3)]

(f) HOW: **ingestion (drink, food, medicine)** (3)

QUESTION 8

(a) NAME: (i) **alkenes (olefins)** (4)
(ii) **aldehydes (alkanals)** (4)

Question 26

(c) (i) GIVE: alcohols have **higher (bigger)** relative **molecular mass** //
and polar **hydroxyl group (polar OH)** / intermolecular **hydrogen bonds** (4 + 3)

(ii) EXPLAIN: **effect (contrib.) of OH less in butanol / hydrogen bonding weaker in butanol / due to longer carbon chain / due to bigger non-polar part** of molecule (6)

OR

effect (contrib.) of OH greater in methanol / hydrogen bonding stronger in methanol / due to shorter carbon chain / due to smaller non-polar part of molecule (6)

[In absence of above 6, allow 3 marks for '*M_r of CH_3OH is double M_r of CH_4 but M_r of C_4H_9OH is only slightly bigger than M_r of C_4H_{10}*']

(iii) DESCRIBE:
methane: virtually **insoluble** //
methanol: completely **soluble (miscible) / miscible in all proportions** //
butane: virtually **insoluble** //
butanol: **slightly (sparingly) soluble / less soluble than methanol** (4 x 3)

['*All alkanes insoluble*' gets (6); '*All alcohols soluble*' gets (3); *stating the relative solubilities of the four compounds* can get (9); *stating the relative solubilities of the four compounds and giving the solubility of one of them* can get (12)]

Question 27

QUESTION 7

(a) NAME: **chloroethane / ethyl chloride** [Accept with number e.g. 1-chloroethane] (5)

(b) CLASSIFY:
W – elimination
X – addition
Y – addition
Z – substitution (4 × 3)

Note: If the letters W, X, Y and Z are not used, the marks may be allocated based on the order of the conversions in the question e.g. the answer *substitution, addition, elimination, substitution* is worth 6 marks.

(c) DESCRIBE: **horizontal test tube with delivery tube connected collection of gas over water** //

Bunsen burner for heating / indication of heating //

aluminium oxide / Al_2O_3 / alumina //

ethanol held at end of test tube (4 × 3)
[minimum of one label required – no labels deduct 3 marks]

Alternatives: (1) flask with delivery tube to collection over water (3) 160 °C (3)
sulfuric acid (3) in mixture (solution) with ethanol (3)

(2) flask with delivery tube to collection over water (3) 200 °C (3)
phosphoric acid (3) in mixture (solution) with ethanol (3)

HOW: shake with **bromine (Br_2)** water solution /
shake with **acidified (H^+, H_2SO_4)** potassium **manganate**(VII) **(permanganate, $KMnO_4$, MnO_4^-)** (3)
goes colourless (decolorised) (N.B. not 'goes clear') (3)

(c) STATE: reaction requires **u.v. light** of energy high enough to homolyse chlorine **to initiate (start)** //
[Allow 6 or 3 for $Cl_2 \xrightarrow{uv} 2\ Cl^\bullet$ only if it is described as the "initiation (starting) step"]
for every photon absorbed very many (thousands of) molecules of a product are formed //
[Statements such as "each photon produces very many (thousands of) radicals" merits no marks as each photon actually only produces two radicals.]
if irradiation (u.v.) is stopped the reaction slows down (stops) / reaction doesn't proceed in the dark /

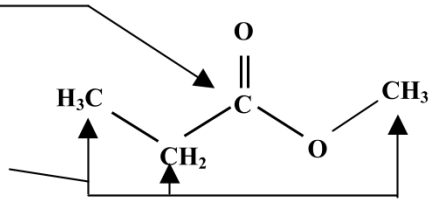
products such as butane / chlorobutane / etc. formed (i.e. alkanes and haloalkanes with a multiple of 2 carbons from C_4 upwards can only be explained by a radical mechanism) //

addition of **radical promoters (radical sources, scavengers, tetramethyl lead, tetra-ethyl lead) alter (speed up) the rate of the reaction** ANY THREE: (2 × 6 + 3)

Question 28

QUESTION 7

(a) IDENTIFY: **planar carbon**



tetrahedral carbon

ANY ONE TETRAHEDRAL: (4)

(4)

(b) NAMES: *alcohol*: **methanol (methyl alcohol)** [*Name essential*]

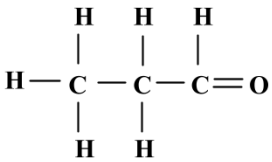
carboxylic acid: **propanoic acid (propionic acid)** [*Name essential*]

TYPE: **substitution / condensation / dehydration** (2 x 6 +3)

(c) (i) **propan-1-ol / 1-propanol / propyl alcohol / *n*-propanol / correct formula**
[Accept propanol]

(ii) **propanal (propionaldehyde)** [*Allow propan-1-al*]

CH_3CH_2CHO / C_2H_5CHO /



(iii) **oxidation / redox / dehydrogenation and oxidation**
[*No marks for 'dehydrogenation' on its own*]

(iv) **sulfuric acid (H_2SO_4) / acidified / H^+**

sodium (potassium) **dichromate (chromate)** (VI) / potassium **manganate** (VII) / potassium **permanganate / correct formula**

(6 + 5 x 3)

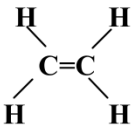
(d) USES: **perfumes (scents) / cosmetics / flavourings (essences) / soap making / drugs (aspirin, paracetamol, amyl nitrite, etc.) / anaesthetics (novocaine, benzocaine, etc.) / insecticides (malathion, pyrethrin, etc.) / clothing (named item) / sails / seat belts / plastics (perspex) / rubs (oil of wintergreen) / solvents for (production of) varnishes (lacquers, enamels, adhesives, glues, paints, inks, etc.) / energy storage / lowering cholesterol / aromatherapy / synthetic fibres / cooking / soap**

ANY TWO: (2 x 3)

Question 29

QUESTION 6

(a) Which: **A / C_2H_4 / ethene / ethylene** (4)

Draw:  **/ $H_2C=CH_2$ / $CH_2=CH_2$** (4)

(In expanded structure, correct bonds must be shown but Hs can be omitted.)

(b) X = **addition** (3)

Y = **addition** (3)

Z = **substitution** (3)

(c) **hydrogen chloride / $HCl_{(g)}$** (3) *Do not allow 'hydrochloric acid'. If 'hydrochloric acid, HCl' given, cancelling applies.*

(d) Reagent: **chlorine / dichlorine / Cl_2** (3)

Conditions: **ultraviolet (uv)** light (3) *"sunlight" not acceptable*

(e) Mechanism: **repulsion by double bond /polarised** HCl **bond / Side-on approach** (3)
splits HCl into ions / heterolytic fission of HCl / HCl $\longrightarrow$ **H^+ + Cl^-** (3)
H^+ uses pi **electrons of double bond to bond with one carbon atom** (3)
leaving other carbon positively charged / forming carbonium ion (carbocation) (3)
Cl^- approaches / attacks / bonds (3)
with C^+* (carbonium ion, carbocation) (3) **To get marks for C^+, the positive charge must be shown on the carbon atom, not on the whole formula.*
(Allow only the last three points for Cl_2 mechanism)

Note: all points can be got from suitable diagrams.

Evidence: **addition using bromine water** (3)

gives 2-bromoethanol (CH_2BrCH_2OH) (3)

OR

addition with bromine water containing a chloride (sodium chloride) (3)

gives 1-bromo-2-chloroethane *(Allow 1-chloro-2-bromoethane)* **(CH_2BrCH_2Cl)** (3)

OR

Another specified anion / chlorine water / HCl in water ($HCl_{(aq)}$, hydrochloric acid) (3)

Product where that anion has added in place of the chlorine (e.g. 2-chloroethanol for chlorine water, and ethanol for $HCl_{(aq)}$)

Correct name cancels with incorrect formula and vice versa. For a correct name, numbers must be present if they are necessary to avoid ambiguity regarding the positions of substituents. However, an ambiguous name does not cancel with a correct formula.

Question 30

QUESTION 9

(a) Aldehyde: **CH_3CH_2CHO / C_2H_5CHO** (4)
(In expanded structure, correct bonds must be shown but Hs can be omitted.)

IUPAC: **propanal** (4) *[Accept propan-1-al]*

Other: **CH_3COCH_3** (3)

Name: **propanone / acetone** (3) *[Accept propan-2-one]*
(In expanded structure, correct bonds must be shown but Hs can be omitted.)

Use: **removing nail varnish / cleaning glassware / solvent for (used in) paints (lacquers, varnishes) / chromatography / recrystallisation / solvent extraction / solvent for nitrocellulose / dry cleaning / stain (grease) removing / industrial solvent (not 'solvent' or 'organic solvent')** (6)

Which: **propanal** (3) *[Accept propan-1-al]* *If name at IUPAC above is wrong, no marks are given for repeating it here. If the candidate simply writes 'the aldehyde', this is acceptable provided the aldehyde was correctly identified at IUPAC above.*

Acid: **propanoic acid / propionic acid** (3) *Given independently of answer to 'Which' above.*

(b) (i) **releases pressure / prevents explosions / allows expansion / releases steam (**hot **water)** (6)
Allow (3) for 'safety'. [Note: 'safety' with one of the (6) mark answers does not involve cancelling.]

(ii) What: mixture of **clove oil** *[Accept eugenol]* (3) and **water** (3)

Describe: **cloudy* / milky** *(not 'creamy')* **/ white / emulsion** (6)
**Allow only (3) if 'cloudy' given with anything other than 'milky', 'white' or 'emulsion' e.g. allow only (3) for 'cloudy green', 'cloudy grey' etc.*

(iii) **flavouring / seasoning / spice / used in food / medicines / dental preparations (dentistry) / sweets / perfume / making vanillin / source of eugenol / antiseptic / disinfectant /** local **anaesthetic / aromatherapy** (6) *[Allow 'cigarettes' and 'soap'.]*