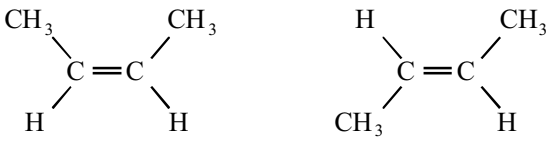
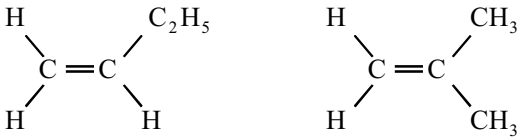
1. (a) (i)

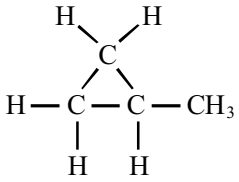


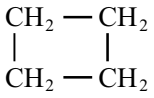
2

(ii) No rotation / restricted rotation around double bond **(1)** 1

(b) (i)







1

(ii) One end of C=C bond has 2 identical atoms / groups attached **(1)**
Or if cyclobutane –
no movement / no C=C **(1)** 1

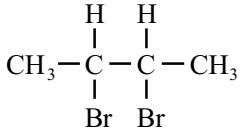
[5]

2. (a) (i) e.g.
$CH_3CHBrCH_2CH_3 + KOH \rightarrow CH_2=CHCH_2CH_3 + KBr + H_2O$
Or
$CH_3CHBrCH_2CH_3 + KOH \rightarrow CH_3CH=CHCH_3 + KBr + H_2O$
(1)
allow ionic equation with OH^- and Br^- 1

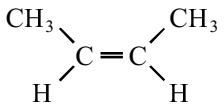
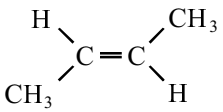
(ii) Elimination **(1)** 1

(b) (i) brown / red-brown / orange / red-orange / yellow to colourless / fades / decolourises / gets paler **(1)** 1

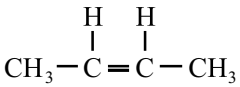
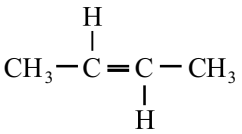
(ii)



2,3-dibromobutane **(1)** *accept 3-bromobutan-2-ol if correct structure drawn for hydroxy product* *2*

(c)   **(1 mark for each)**

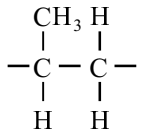
allow: 2

(ii) Restricted (or 'no') rotation about double bond /
2 different groups at each end of double bond **(1)**
geometrical / cis-trans **(1)** 2

[9]

3. (a) Group of compounds with the same general
formula **(1)** that
differ by $-CH_2-$ **(1)**
Same or similar **chemical** properties / same
functional group **(1)** 3

(b) (i) 

At least one repeat unit **(1)**
evidence of extension of chain **(1)** 2
consequential on correct repeat unit

(ii) CH_2 **(1)**
empirical formula of propene/ the repeat unit **(1)**
since polymer made by addition reaction / no loss of
small molecules **(1)** 3

(c) Different chain lengths / areas of crystalline and amorphous structure **(1)** 1

(d) (i) C-F bond strong / high bond enthalpy / bond not
easily broken / steric hindrance by fluorine around carbon **(1)** 1

(ii) Non–stick coatings e.g. in saucepans, in pipes, on skis,
stain–proofing of fabrics, waterproof clothing. **(1)** 1

(e) **Only** single / sigma bonds in ethane **(1)**

Ethene **also** has π bond **(1)**
π bond weaker (and breaks) / electrons in π bond more accessible **(1)** 3

[14]

4. (a) It is a mixture / not a single compound 1

(b) (i) 2,4-dimethylpentane 1

(ii) C_7H_{16} 1

(iii) More volatile / lower boiling point / vaporises more readily / branched so doesn't knock / higher octane number 1

(iv) Heat / high temperature / ≥ 200 °C **(1)**
Silica / alumina (catalyst) /zeolites **(1)** 2

(v) *Diagram should show:*

Test tube containing paraffin absorbed on suitable absorbent – **(1)**
absorbent can be just shown in the diagram

Aluminium oxide catalyst **(1)**
Heat catalyst **(1)**
Recognition of collection of gas over water /gas syringe **(1)** 4

Penalties
–1 for poor diagram

(c) (i) $(CH_3)_2C = CH_2$
ACCEPT $(CH_3)_2CCH_2$ 1

(ii) Elimination 1

(iii) Potassium hydroxide / KOH / NAQH **(1)**
Ethanolic / alcoholic solution + heat / reflux **(1)** 2

[14]

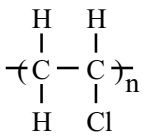
5. (a) (i) $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$ **(1)**

$C_2H_4 + Br_2 \rightarrow CH_2BrCH_2Br$ *ALLOW* $C_2H_4Br_2$ **(1)** 2

IGNORE STATE SYMBOLS

(ii) (Free) radical / homolytic **(1)** substitution **(1)**
Electrophilic **(1)** addition **(1)** 4

(b) (i)



1

(ii)

Water pipes
window or door frames
clothing
bottles
coating on electrical cables
flooring
NOT plastic / PVC / carrier bags

Any one

1

(iii) Persists in the environment / persisting as litter

OR non-biodegradable / not broken down by bacteria **(1)**

because of strong C-Cl bond **(1)**

OR

combustion / burning **(1)**

produces toxic gases /acidic gases/HCl **(1)**

NOT chlorine

2

[10]

6. (a)

- A species with a lone pair / pair of electrons **(1)**
  NOT "negative ion" alone or as an alternative
- which it uses / donates to form a (dative) covalent bond **(1)**

2

(b) (i)

- Ammonia / NH_3 (in ethanol) **(1)**
- heat **(1)** **NOT** heat under reflux *UNLESS* in a sealed tube

  If a temperature is quoted it must be greater than 100°C
- in sealed tube / under pressure / concentrated **(1)**

  If a pressure is quoted it must be greater than 1 atm

Conditions are dependent on correct reagent.

If ammonia and an additional reagent **max (1)** for two correct conditions.

3

(ii) Carbon-bromine bond stronger / higher bond enthalpy than carbon – iodine / Ea for C-Br is higher than C-I

IGNORE any extra explanations involving the alkyl groups 1

(c) Identify bonds broken **and** made **(1)**

e.g. Energy in + 464 or + 3340

AND Energy out (-) 656 or (-) 3532 **(1)**

Energy needed to break bonds – energy released to make bonds = 36 **(1)**

e.g. C-I + 464 – 656 = + 36

or C-I + 3340 – 3532 = + 36 **(1)**

Correct evaluation dependent on use of 36 **(1)**

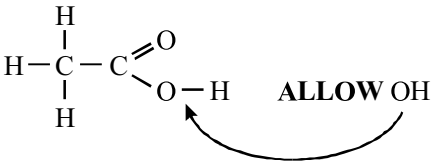
i.e. C-I = 228 kJ mol^{-1} **(1)**

Correct answer with some correct working **(3)**

If final answer is negative max **(2)**

If 36 is on the wrong side, then 156 max 2 (-156 **(1)**)

If miss out 36, then ±192 **max 1** 3

(d) 

1

[10]

7. (a) (i) 1,2-dichloroethane 1

(ii) $CH_2 = CHCl$ / CH_2CHCl 1

(iii) e.g. dissolve / bubble HCl in water / absorb in an alkali / condense the HCl(g) 1

(b) (i) Species having unpaired electron 1

(ii) Action of UV radiation/sunlight / named initiator / photoflood 1

(c) (i) Water / OH^- 1

(ii) Unshared / lone pair of electrons on a legitimate nucleophile based on (c)(i) **(1)**

(c)(i) "nucleophile" attacks / forms bond with **C** of C – Cl **(1)** 2

(iii) Chloride ion / Cl^- 1

(iv) Add silver nitrate solution **(1)**
white ppt **(1)** 2

[11]

8. (a) (i) a particle / species /group with an unpaired electron /OWTTE 1

(ii)  1

(iii) homolytic 1

(b) B and C 1

(c) (i) $C1_2 + CH_4 \rightarrow CH_3Cl + HCl$ 1

(ii) $+242 + 4 + -339 = -93$ kJ mol^{-1}
(A + B + F)
OR
$+4 - 97 = -93$ kJ mol^{-1}
(B + C)
Method **(1)**
answer with units **(1)** 2

(d) (i) -242 kJ mol^{-1} 1

(ii) Exothermic because a bond has been formed. 1

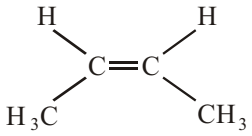
(e) Less endothermic **(1)**
the bond is weaker **(1)** 2

[11]

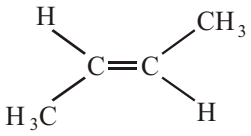
9. (a) (i) $CH_4 + C1_2 \rightarrow CH_3Cl + HCl$ **(1)** 1

(ii) UV (radiation) / Sunlight **(1)** Not light 1

(b) (i)



(1)



(1) 2

(ii) restricted rotation around double bond **(1)**
Allow no rotation at room temperature
two different groups on each double bonded carbon **(1)** 2

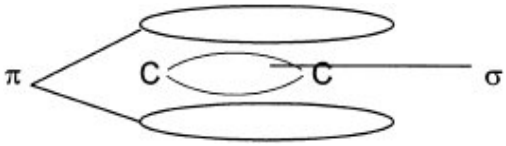
(iii) 2,3-dichlorobutane **(1)** 1

[7]

10. (a) (i) $C_2H_6(g)/(l) \rightarrow C_2H_4(g) + H_2(g)$
If a state symbol is missing **(0)**
If (aq) **(0)** 1

(ii) At high pressure reaction goes in direction to reduce pressure/to oppose change by Le Chatelier's principle **(1)**
towards side with fewer molecules/moles **(1)** 2

(b) Shapes of orbitals between and above carbon



If p orbitals drawn msut show overlapping

Shapes **(1)** ACCEPT crescents for π bonds NOT lines for σ bond 2
Labels **(1)**

(c) Addition of bromine **water/solution (1)**
from yellow/brown/orange to **colourless (1)**
OR
acidified potassium manganate(VII) **(1)**
from pink/purple to **colourless (1)** 2

(d) Addition **(1)**
Elecrophilic/electrophile *OR* appropriate *explanation* **(1)** 2

[9]

11. (a) H_2 / hydrogen *NOT* H **(1)**

Ni / nickel

OR platinum / Pt / palladium / Pd **(1)**

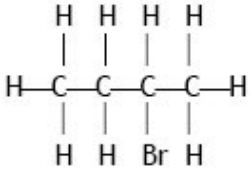
(Ni) 140 – 180 ° C / heat **(1)** 3

OR (Pt / Pd) room temperature

If no reagent but other parts correct **(1)**

Incorrect reagent **(0)**

(b) (i)

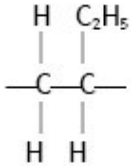


1

(ii) electrophile / electrophilic *IGNORE any reference to addition* 1

(c) potassium manganate(VII) / potassium permanganate / MnO_4^- / manganate(VII) ions *IGNORE* acid or alkali 1
ACCEPT name or formula

(d)



Correct structure **(1)** – *only one repeat until identified*

Continuation **(1)**

IGNORE $(\ )_n$ 2

[8]

12. (a) (i) (Free) radical
ACCEPT homolytic radical
NOT radical ion 1

(ii) $CH_3CH_3 + Br_2 \rightarrow CH_3CH_2Br + HBr$
OR
$C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$

ACCEPT multiple substitution only if the equation balances
Can be full structural formula
If H_2 is one product then **(0)** 1

(b) (i) $CH_2 = CH_2 + Br_2 \rightarrow BrCH_2CH_2Br$ / CH_2BrCH_2Br /

Ethene shown with double bond + Br_2 **(1)**
product **(1)** 2

(ii) 1,2 (–) *dibromoethane only – mark independently of (i)*
IGNORE punctuation 1

QWC (c) Ethene has a π / double bond **(1)**

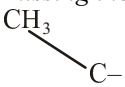
Ethane has σ only / single only / no π / no double bond **(1)**

π (in ethene) weaker than C–H (in ethane) / high electron density in C=C **relative to C–H** bond **(1)** 3

[8]

13. (a) (i)

Can show C in straight line if H's clearly cis or trans.
If H is missing once but bond is shown, no penalty.
If all H's missing then ***(1)*** *only awarded for both structures*

ALLOW 

2

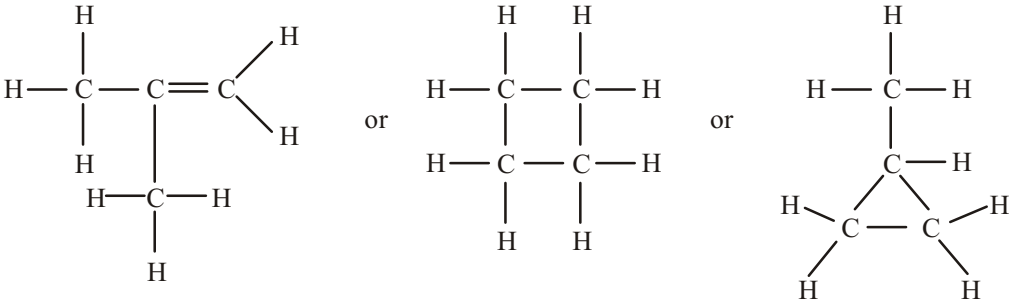
(ii) (Both have) no/restricted rotation about C=C (rotation would require π bond to break) **(1)**

but but-1-ene has two identical groups on a doubly bonded carbon atom **(1)**

but-2-ene does not **(1)**

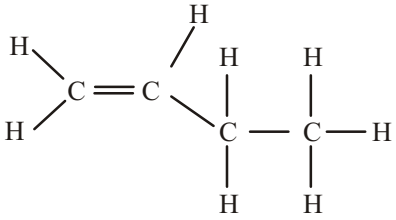
OR other way round 3

(iii)



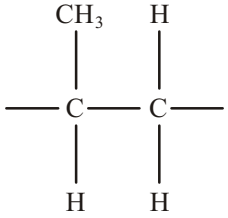
or or

ALLOW



Do not need to show all bonds eg can be $-CH_3$, $-C_2H_5$ 1

(b) (i)



Skeleton **(1)**
Indication of continuation conditional on a two carbon saturated chain in the skeleton. **(1)** 2

(ii) Unreactive *OR* non-biodegradable **(1)**

So occupies / fills site *OR* remains in the site *OR* causes visual pollution **(1)**
2nd mark consequential on 1st
*NOT "*Do not decompose/decay*" for 1st mark but allow 2nd mark* 2

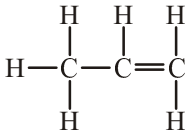
[10]

14. (a) Alkene 1

(b) $CH_2=CHCH_2CH_3$ / $CH_3CH=CHCH_3$ / $CH_2=C(CH_3)_2$ / $CH_2=C(CH_3)CH_3$
double bond need not be shown
ACCEPT displayed formula
Mark independently of a
Watch for incorrect numbers of H in the middle of the chain 1

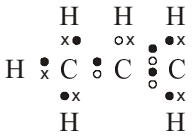
[2]

15. (i)



1

(ii)



ALLOW all dots or crosses
ALLOW TE for a butene/pentene in (a)(i)
IGNORE circle 1

[2]

16. $(CH_3)_2C=CH_2$
ALLOW displayed formula **(1)**
ALLOW $C(CH_3)_2=CH_2$
$CH_3C(CH_3)=CH_2$
$CH_3CCH_3=CH_2$
$CCH_3CH_3=CH_2$
$CH_3CH_3C=CH_2$

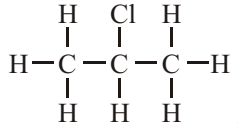
double bond need ***not*** *be shown,* but if **single** bond displayed **(0)**

(2-)methylpropene
2 - methylprop - 1 - ene
2 - methylprop - 2 - ene
} *IGNORE punctuation, spaces etc*

Mark independently
No transferred error allowed 2

[2]

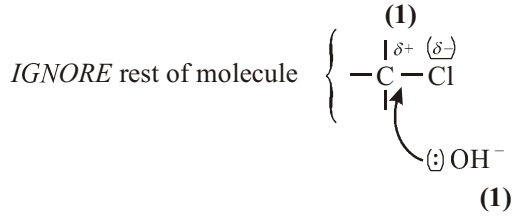
17. (a) (i) 2(-)chloropropane



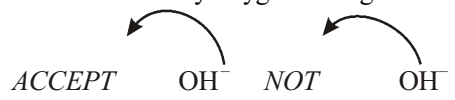
No internal TE from name to structure

MUST be fully displayed 2

(ii)



Mark independently
Must attack the carbon
ALLOW attack by oxygen or negative charge or lone pair 2



NOT C^+

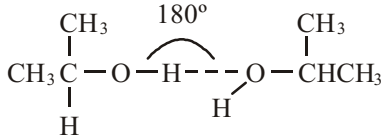
(b) (i) Elimination
NOT in conjunction with additional incorrect information
eg "nucleophile" 1

(ii) Sodium hydroxide / NaOH/potassium hydroxide / KOH **(1)**
Any additional incorrect reagent ***(0)***
NOT alkali on its own for 1st mark

Alcoholic solution / ethanolic solution **and** heat / warm / reflux **(1)**
2nd mark is dependent on mention of correct reagent or "alkali"
"aqueous" negates 2nd mark eg KOH(aq) + heat **(1)** – *ie reagent mark*
NaOH(alc) + heat **(2)** 2

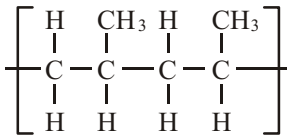
(c) (i) Hydrogen/H bonding 1

(ii)



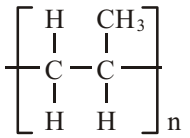
H-bond and rest of molecule ***(1)***
angle must be between 3 atoms for a correct H bond ***(1)***
ALLOW HOH 106-108° 2

(d) (i)



IGNORE any "n" in this diagram

Brackets optional but continuation must be shown
4 carbon chain with 6Cs overall in structure **(1)**
methyl groups can be on C_1 and C_3, C_1 and C_4, C_2 and C_4, C_2 and C_3 **(1)**



1 max 2

(ii) (big molecule) so large number of electrons **(1)**

Hence **large/strong van der Waals'** forces
(to be overcome to change state)**(1)** 2

[14]

18. (a) (i) (2-)methylbut(a)-1,3- diene

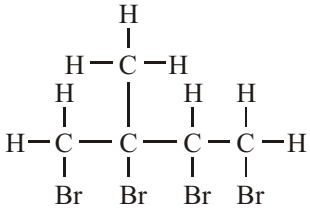
(1) **(1)**

IGNORE punctuation
ALLOW 1 max if correct answer is pre-fixed by cis / trans 2

(ii) From orange/yellow/brown to colourless **(1)**
NOT red *NOT* clear 1

(iii) addition **(1)**
electrophilic **(1)**
in either order 2

(iv)



Methyl group need not be displayed 1

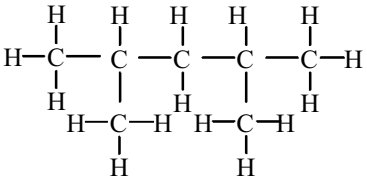
(b) (i) Van der Waals' (forces)
ACCEPT Van der Walls
NOT vdw 1

(ii) Q because (unbranched) so greater area of **contact** / **closer packing**
(between molecules) **(1)**

hence greater Van der Waals/vdw forces **(1)**
2nd mark dependent on 1st
Incorrect isomer chosen ***(0)***
Fully correct reverse argument ***(2)*** 2

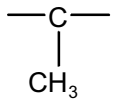
[9]

19. (a) (i)

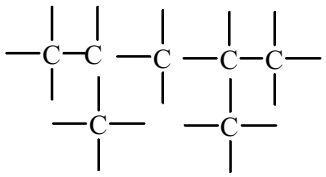


1

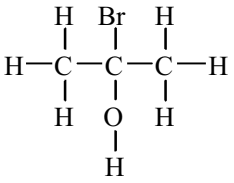
Accept CH_3 in branches
But do not allow bond directly to H
i.e.



Reject

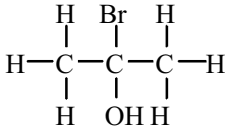


(ii)

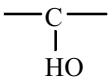


1

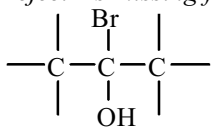
Accept



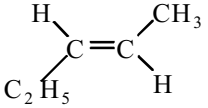
Reject bond pointing directly to H i.e.
in OH i.e.



Reject Hs missing from carbons i.e.

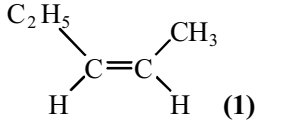


(b) **Isomer 1**



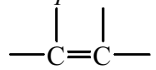
(1)

Isomer 2

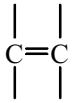


(1)

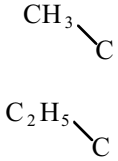
Accept 90° bond angles e.g



OR



ACCEPT



If incorrect alkene eg but-2-ene, allow **(1)** for both cis and trans isomers 2

[4]

20. (a) (i) $(C_2H_6 + Br_2) \rightarrow C_2H_5Br + HBr$

OR

multiple substitution e.g.

$C_2H_6 + 2Br_2$ $\rightarrow C_2H_4Br_2 / CH_3CHBr_2/CH_2BrCH_2Br + 2HBr$

$C_2H_6 + 3Br_2$ $\rightarrow C_3H_3Br_3 + 3HBr$ etc 1

Accept $CH_3C\ H_2Br$ or full structural formula

Reject $C_2H_6 + 3Br_2 \rightarrow 2C + 6HBr$

(ii) $(C_2H_4 + Br_2) \rightarrow CH_2BrCH_2Br$ 1

Reject $C_2H_4Br_2$

(b) (i) ethane C– H bond **and** ethene C=C bond **(1)**

ALLOW carbon–carbon if double in type of bond

ethane type: σ/sigma **and** ethene type: π/pi **(1)**

OR mark horizontally 2

Reject σ and π for ethene

(ii) π/pi bond is weaker (than the σ/sigma bond) 1

Accept π/pi bond requires less energy to break
OR
π/pi bond has lower bond enthalpy

Reject π breaks more easily

Reject π bond is weak

OR
π/pi bond has higher electron density (than the σ/sigma bond)

Accept π/pi bond has more accessible electron density

[5]

21. (a) (i) 2,2,4-trimethylpentane
Ignore punctuation (Commas and hyphens may be interchanged) 1

Accept 2,4,4 - trimethylpentane

Reject pentan for pentane
2-dimethyl-4
methylpentane
2,2-dimethyl-4-methyl
pentane
2-methyl-4,4-dimethyl
pentane
2,4-trimethylpentane

(ii) C_4H_9 1

Accept $C_8H_{18} \rightarrow C_4H_9$

(iii) C_2H_4 1

Reject CH_2CH_2

(iv) Positive because energy is required to break (C–C) bonds
(and not completely replaced (from new bonds made))
OR Positive because cracking requires (continuous) supply of
heat so must be endothermic 1

Accept two C–C bonds are broken and one C=C made

Reject positive because it only occurs at high temperature

(v) $C_8H_{18} + 17/2\ O_2 \rightarrow 8CO + 9H_2O$

OR $2C_8H_{18} + 17\ O_2 \rightarrow 16CO + 18H_2O$

OR $C_8H_{18} + 9/2\ O_2 \rightarrow 8C + 9H_2O$ (or doubled)

Oxygen on left and correct formulae of products **(1)**
balancing **(1)**
Second mark depends on first and a sensible hydrocarbon formula must be used. 2

Accept balanced equations including CO and/or C with CO_2
17/2 can be written 8.5 or 8½
Allow balanced equations based on C_8H_{18} with a smaller alkane in the products for 1 mark eg
$C_8H_{18} + O_2 \rightarrow CO + C_7H_{16} + H_2O$ ***(1)***

(b) (i) Increase in pressure: No effect as number of moles/molecules (of gas) doesn't change during reaction **(1)**

Increase in temperature: **more NO** as forward reaction endothermic OWTTE **(1)**

One mark for two correct predictions with incorrect explanations 2

Reject increase in temperature moves equilibrium to the right

(ii) Rate increases as converter gets hotter (as reaction is exothermic) 1

(iii) N_2 / nitrogen is (major) part of air/ N_2 unreactive/ not poisonous/ not a greenhouse gas / not acidic 1

Accept correct harmful properties of other 3 gases

(iv) Line from level of reactants to maximum labelled E_A **(1)**

Curve of similar shape above existing curve, starting and finishing at same levels, with maximum above original maximum **(1)** 2

[12]

22. (a) (i) A and/or propene 1

Accept prop-1-ene

Reject A and any other letter

(ii) B C and D (any order)
3 correct for **2 marks**
2 correct for **1 mark**

1 letter, correct or incorrect	O eg	B
2 letters both correct	1	BC
2 letters 1 correct 1 wrong	O	BE
3 letters, all correct	2	BCD
3 letters, 2 correct 1 wrong	1	BCE
3 letters, 1 correct 2 wrong	O	ABE
4 letters, 3 correct 1 wrong	1	BCDE
4 letters, 2 correct 2 wrong	O	ABDE
5 letters	O	ABCDE

2

(b) (i) 2–bromopro**a**ne 2 (–) bromo (–) propane
2 Bromo Propane 2, bromopropane 1

Reject bromopropane
Reject bromo-2-propane
Reject 2-bromopropene

(ii) poly(propene) or polypropene 1

Accept polly(propene)
Accept polypropylene

Reject poly porpene
Reject polypropane

(c) (i) potassium/sodium hydroxide **(1)**

(concentrated)
ethanol(ic)/alcoholic AND heat/reflux 2

Accept KOH/NaOH

Reject alkali on its own

Reject any mention of water/aqueous/pressure (–1)

(ii) Elimination (reaction) 1

Reject any qualification of elimination e.g nucleophilic / electrophilic cracking

(d) (i) $Cl_2 \rightarrow 2Cl^{\bullet}$
Ignore state symbols 1

Reject not 2 Cl(g)
Reject $Cl_2 \rightarrow 2Cl$

(ii) $C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$
Ignore state symbols 1

Reject $2Cl^\circ + C_3H_8 \rightarrow C_3H_7Cl + HCl$

(iii) 2 (,) 3 (–)dimethyl butane **(1)** Ignore punctuation
Reaction between two
CH_3—CH—CH_3 **(1) dot must be shown on central carbon atom**
Termination **(1)** 3

Accept $C_3H_7^\circ + C_3H_7^\circ \rightarrow C_6H_{14}$

Accept chain termination

Reject 2,3 methylbutane

Reject $CH_3CHCH_3^\circ$

[13]

23. (a) (i) Amount of $CO_2 = \frac{53}{24000}$
$= 0.0022$ (mol)

Accept 0.002 with working

Amount of $H_2O = \frac{0.020}{18}$
$= 0.0011$ (mol) 3

Amount of C = 0.0022 mol = 0.0265(g)
Amount of H = 0.0022 mol = 0.0022(g)

Any one of above needed for 1st mark **(1)**

Mass of O in Z = 0.0714 (g)
OR amount of O in Z = 0.0045 (mol)
Some clear indication they have done it correctly **(1)**

Empirical formula CHO_2 **(1)**

(ii) $(CHO_2)_y = (12 + 1 + 2 \times 16)y = 90$
Y = 2
Molecular formula $C_2H_2O_4$
Allow TE from (i)
Allow $C_2H_2O_4$ with no working
Allow any indication they know how to do it
eg 'n × empirical mass = molar mass' 1

Reject $C_4H_{10}O$ only (no connection with (i))

(iii) (0.01 mol **Z** contain $\frac{20.0 \times 1.00}{1000}$ =) 0.02 (mol) **(1)**

Accept formula alone for Z

CO_2H
|
CO_2H **(1)** 2

Accept fully/partially displayed formula

(iv) **W** $CH_2{=}CH_2$ **(1)**
X CH_2BrCH_2Br **(1)**
Y CH_2OHCH_2OH **(1)**
Look out for TE and internal TE
Eg **W** CH_3CHCH_2
X $CH_3CHBrCH_3$
Y $CH_3CHOHCH_3$
is worth **1 max** 3

Accept full credit for consistent answers based on other gaseous alkenes eg $CH_3CHOHCH_2OH$ etc

(v) $C_{20}H_{42} \rightarrow C_{18}H_{38} + C_2H_4$ **(1)**
Allow $C_{17}H_{36} + C_3H_6$ OR $C_{16}H_{34} + C_4H_8$ 1

*Accept TE for **W***

Accept any balanced equation including ethane

(b) Potassium manganate((VII))/KMnO4 **(1)**
Sulphuric acid/H_2SO_4 consequential on potassium manganate **(1)**
ALLOW 'acidified potassium manganate((VII))' for both marks 2

Accept TE for W alkene and corresponding monohydric alcohol
1. H_2SO_4/sulphuric acid
2. H_2O/water

Reject other Roman numerals after managate

[12]

24. (a) (i) 2-bromobutane
the "2" must be in front of "bromo"
Ignore punctuation and capitals 1

(ii) $CH_3CHBrCH_2CH_3 + KOH \rightarrow CH_3CHOHCH_2CH_3 + KBr$
OR
$CH_3CHBrCH_2CH_3 + OH^- \rightarrow CH_3CHOHCH_2CH_3 + Br^-$ 1

Accept C_2H_5 instead of CH_2CH_3

Allow K^+ as spectator ion

Reject eqns with NaOH

(iii) water / H_2O / aqueous ethanol 1

Accept C_2H_5OH (aq) / aqueous alcohol/KOH(aq)/aqueous
Do not penalise use of NaOH(aq) again

Reject just "ethanol / ethanolic / alcoholic (KOH)"

(iv) nucleophilic substitution (both needed) 1

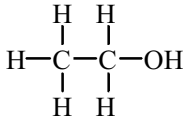
Accept reasonable phonetic spelling

(b) (i) $CH_3CHBrCH_2CH_3 + OH^- \rightarrow CH_3CH{=}CHCH_3 + H_2O + Br^-$
OR
$CH_3CHBrCH_2CH_3 + OH^- \rightarrow CH_2{=}CHCH_2CH_3 + H_2O + Br^-$
Double bond need not be shown 1

Accept C_2H_5 instead of CH_2CH_3

Ignore spectator ions

(ii) Ethanol / C_2H_5OH / CH_3CH_2OH /



1

Accept alcohol OR Ethanolic/alcoholic
Accept KOH/NaOH

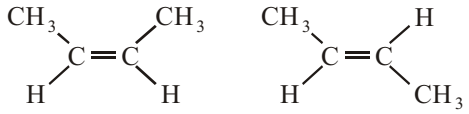
Reject C_2H_6O

Reject any mention of water/aqueous

(iii) elimination
ignore "nucleophilic" 1

Reject electrophilic elimination

(c) (i) 1



bond to H of CH_3 on left carbon
structure with 90° bond angles

(c) (ii) no / restricted rotation around double bond / C=C /π – bond (1)
has two different groups joined to **each** C (of double bond) OR each (carbon of C=C) has a CH_3 and a H (1) 2

limited rotation

on the carbon

(d) (i) nickel / Ni
OR platinum / Pt
OR palladium / Pd 1

(d) (ii) butane / $CH_3CH_2CH_2CH_3$ 1

C_2H_5 for CH_3CH_2

JUST "C_4H_{10}"

[12]

25. (a) (i) (Concentrated) sulphuric acid/H_2SO_4 **(1)**
Water/H_2O **(1)**
Any order 2

Accept phosphoric acid
1 HBr 2 NaOH/KOH (2)
H_2SO_4 + NaOH/KOH (1max)
H_2O and high T and P and catalyst (1 max)

Reject dilute/aq sulphuric acid
H_2SO_4 + $Na_2Cr_2O_7$ (0)
H_2O alone (0)
H_2O + × (eg H_2O_2) (0)

(ii) Butan(e) -1,2-diol 1

Ignore punctuation
1,2-butan(e)diol
1,2-dihydroxybutane

Reject buta-1,2-diol
Reject but-1,2-diol
Reject 1,2-diolbutan(e)
Reject any formula

(iii) 1,2-dibromobutane 1

Ignore punctuation

Reject any formula

(iv) Hydrogen bromide/HBr
Ignore (aq) 1

Accept KBr + H_2SO_4/H_3PO_4
Accept any other metal
Accept bromides

(b) **Two** reactants come together to make **one** product 1

Accept one reagent added across double bond
Accept use judgement but in general look for 'two…become one'
Accept 'two or more reactants give one product'

Reject 'adding 1 atom'
Reject just 'unsaturated becomes saturated'
Reject just 'the double bond breaks'
Reject '2 molecules are joined'

(c) (i) A species/molecule/ion with a space for/which can accept (a pair of) electron**s** (to make a dative covalent bond) 1

Accept an electron deficient entity
Accept electron deficient ion

Reject just 'a lover of negative charge'
Reject positive ion
*Reject electron deficient **element***

(ii) $Br^{\delta+} - Br^{\delta-}$ / $Br^{\delta+}$ 1

Accept Br^+

Be generous on symbols for delta

Reject Br_2

(d) (i) Reaction 2 — 1

Reject two answers

(ii) Oxidation number of carbon increases
or
oxygen is added (to the organic compound) — 1

Reject loss of electrons alone / loss of electrons and addition of oxygen

(e) (i) Butane/$CH_3\ CH_2\ CH_2\ CH_3$ — 1

Accept displayed formulae
Accept C_2H_5 instead of $CH_3\ CH_2$

Reject C_4H_{10}

(ii) Hydrogen **(1)**
Nickel **(1)** — 2

Accept H_2
Accept Ni
Accept platinum/Pt or palladium/Pd

Reject H

(iii) Chlorine **(1)**
UV/ultraviolet/sunlight **(1)** — 2

Accept Cl_2
Accept visible light

Reject just 'light'

[15]

26. (a) (i) Any two of

- (same) general formula

  *Accept (Same) **general** molecular formula*

  Reject (Same) molecular formula

- (successive) members differ by CH_2
- (same) functional group/ (similar/same) chemical properties/reactions
- regular trend in physical properties

  Reject same physical properties

  Reject reference to a specific reaction e.g. same reaction with chlorine

IGNORE "same properties" 2

(ii) alk**e**ne(s) 1

Reject C=C
*Reject alk**a**ne*

(iii) electrophilic addition **(1)** both needed

IGNORE heterolytic and penalise homolytic

hydrogen chloride/HCl **(1)** 2

Reject (Dilute) hydrochloric acid/dilute HCl /HCl(aq)

(b) same **molecular** formula **(1)**

Accept same numbers of each atom

different structural formulae/displayed formulae/ arrangement of atoms **(1)** 2

Accept different structure

Reject different arrangement in space

(c) 1-bromopropane faster **(1)**
Stand alone

Accept reverse statement

Any answer which gives 1-chloropropane as faster scores zero overall

because **C–Br** bond weaker (than C–Cl) **(1)**

Accept reverse argument

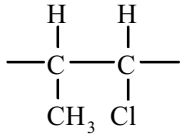
Reject if no reference to carbon-halogen bond

IGNORE attempted explanations of why C–Br bond weaker

therefore lower activation energy/E_{act} **(1)**
[Lower E_{act} must be related to C–X bond] 3

Accept reverse argument

(d)



2 carbon chain with continuation bonds in repeat unit **(1)**

All other atoms correct **(1)**

IGNORE subscript n

IGNORE where the bond to the CH_3 goes e.g.

CH_3 is fine 2

*If more than one repeat unit given and number of repeat units stated or the repeat unit identified **(2)***
If repeat unit not stated or identified can score 2nd mark only

Reject 3 carbon chain
Or
Any repeat unit containing a double bond scores zero

(e) Restricted rotation around double bond **(1)**

Accept no rotation/double bond cannot rotate (at room temperature)

1-chloropropene has two different groups on **both** carbons/**each** carbon (in the double bond)(but propene does not) **(1)** 2

*Accept propene has two identical groups on **one** carbon (of the double bond) (but 1-chloropropene does not)*

[14]

27. (a) C 1

(b) D 1

(c) A 1

(d) D 1

[4]

28. (a) A 1

(b) C 1

[2]

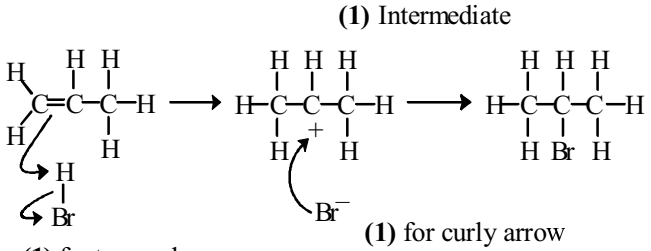
29. B

[1]

30. C

[1]

31. (a) (i)



3

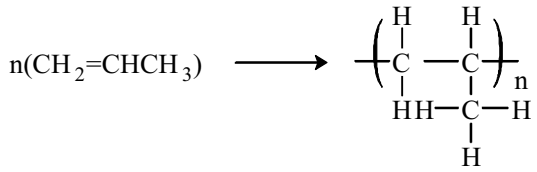
Reject inaccurate placing of curly arrows

(ii) The secondary carbocation/carbonium ion is more stable than the primary (so forms when H^+ adds)
OR
The secondary carbocation/carbonium ion is stable because the methyl groups are electron donating 1

(iii) 2-bromopropane 1

(b) Acidified potassium manganate(VII) / potassium permanganate / KMnO4((aq)) 1

(c)



balanced and double bond broken **(1)**
CH_3 on side chain **(1)** 2

Reject CH_3 in unbranched chain

(d) Poly(propene) is non-biodegradable / won't break down in wet conditions **(1)** 1

(e) (i) propagation 1

(ii) C_6H_{14} / hexane /
Structural, displayed or skeletal formulae of hexane 1

[11]