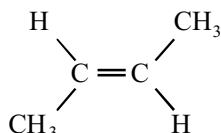
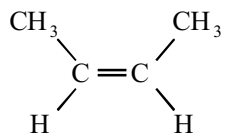


1. (a) (i)

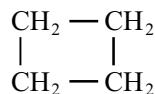
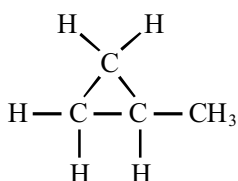
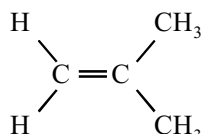
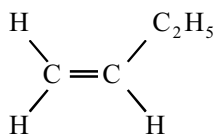


2

(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)

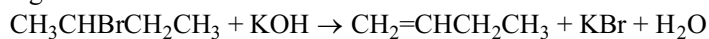
**Or** if cyclobutane –  
no movement / no C=C (1)

1

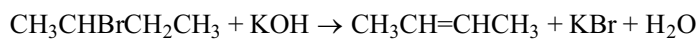
[5]

2. (a) (i)

e.g.



Or



(1)

*allow ionic equation with OH<sup>-</sup> and Br<sup>-</sup>*

1

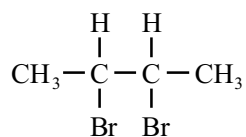
(ii) Elimination (1)

1

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

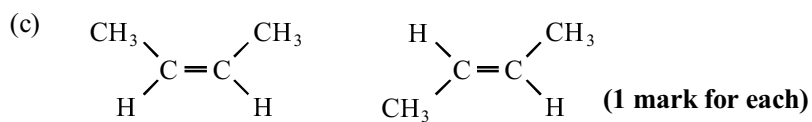
1

(ii)

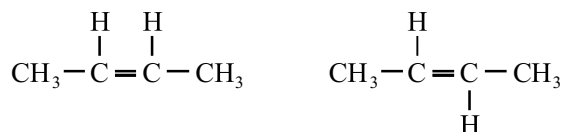


2,3-dibromobutane (1) *accept 3-bromobutan-2-ol if correct  
structure drawn for hydroxy product*

2



allow:



2

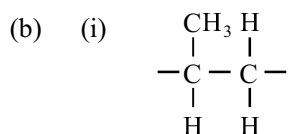
- (ii) Restricted (or 'no') rotation about double bond /  
2 different groups at each end of double bond **(1)**  
geometrical / cis-trans **(1)**

2

[9]

3. (a) Group of compounds with the same general  
formula **(1)** that  
differ by  $-\text{CH}_2-$  **(1)**  
Same or similar **chemical** properties / same  
functional group **(1)**

3



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

2

- (ii)  $\text{CH}_2$  **(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  $\pi$  bond (1)  
 $\pi$  bond weaker (and breaks) / electrons in  $\pi$  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 /  $\geq 200$  °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



- (ii)
- |  |                |   |
|--|----------------|---|
| Water pipes<br>window or door frames<br>clothing<br>bottles<br>coating on electrical cables<br>flooring<br><b>NOT</b> plastic / PVC / carrier bags | <b>Any one</b> | 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<sub>3</sub> (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 /  $E_a$  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<sup>-1</sup> (1)

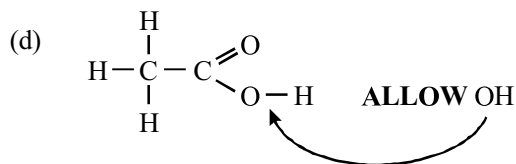
Correct answer with some correct working (3)

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

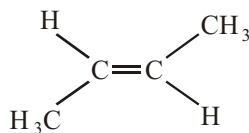
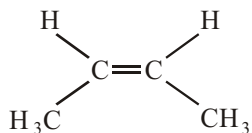


[10]

7. (a) (i) 1,2-dichloroethane 1  
 (ii) CH<sub>2</sub> = CHCl / CH<sub>2</sub>CHCl 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 <sup>-</sup>   | 1 |             |
|           | (ii)  | Unshared / lone pair of electrons on a legitimate nucleophile based on (c)(i) <b>(1)</b>  |   |             |
|           |       | (c)(i) "nucleophile" attacks / forms bond with C of C – Cl <b>(1)</b>   | 2 |             |
|           | (iii) | Chloride ion / Cl <sup>-</sup>  | 1 |             |
|           | (iv)  | Add silver nitrate solution <b>(1)</b><br><b>white ppt (1)</b>  | 2 | <b>[11]</b> |
| <b>8.</b> | (a)   | (i) a particle / species /group with an unpaired electron /OWTTE  | 1 |             |
|           |       | (ii) $\begin{matrix} ++ \\ +\text{Cl}+ \\ ++ \end{matrix}$  | 1 |             |
|           |       | (iii) homolytic   | 1 |             |
|           | (b)   | B and C   | 1 |             |
|           | (c)   | (i) $\text{C}_1_2 + \text{CH}_4 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$  | 1 |             |
|           |       | (ii) $+242 + 4 + -339 = -93 \text{ kJ mol}^{-1}$<br>(A + B + F)<br><i>OR</i><br>$+4 - 97 = -93 \text{ kJ mol}^{-1}$<br>(B + C)<br>Method <b>(1)</b><br>answer with units <b>(1)</b> | 2 |             |
|           | (d)   | (i) $-242 \text{ kJ mol}^{-1}$  | 1 |             |
|           |       | (ii) Exothermic because a bond has been formed.   | 1 |             |
|           | (e)   | Less endothermic <b>(1)</b><br>the bond is weaker <b>(1)</b>  | 2 | <b>[11]</b> |
| <b>9.</b> | (a)   | (i) $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$ <b>(1)</b>  | 1 |             |
|           |       | (ii) UV (radiation) / Sunlight <b>(1)</b> Not light   | 1 |             |

(b) (i)



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)*

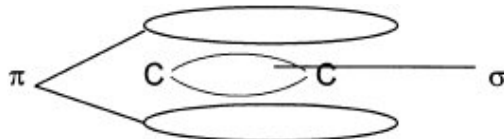
If (aq) (0)

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 must show overlapping*

Shapes (1) ACCEPT crescents for  $\pi$  bonds NOT lines for  $\sigma$  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)

Electrophilic/electrophile *OR* appropriate *explanation* (1)

2

[9]

11. (a) H<sub>2</sub> / 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)
- $$\begin{array}{cccc}
 & \text{H} & \text{H} & \text{H} & \text{H} \\
 & | & | & | & | \\
 \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} - \text{H} \\
 & | & | & | & | \\
 & \text{H} & \text{H} & \text{Br} & \text{H}
 \end{array}$$
- (ii) electrophile / electrophilic *IGNORE any reference to addition* 1

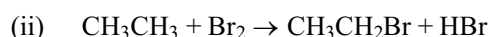
- (c) potassium manganate(VII) / potassium permanganate / MnO<sub>4</sub><sup>-</sup> / manganate(VII) ions *IGNORE acid or alkali* 1  
*ACCEPT name or formula*

- (d)
- $$\begin{array}{cc}
 \text{H} & \text{C}_2\text{H}_5 \\
 | & | \\
 - \text{C} & - \text{C} - \\
 | & | \\
 \text{H} & \text{H}
 \end{array}$$
- Correct structure (1) – *only one repeat until identified*  
 Continuation (1)  
*IGNORE ( )<sub>n</sub>* 2

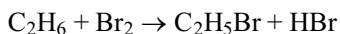
[8]

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





OR

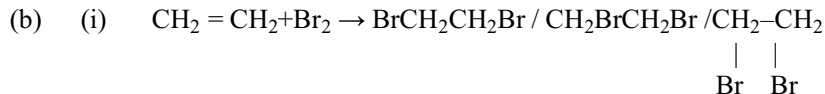


ACCEPT multiple substitution only if the equation balances

Can be full structural formula

If  $\text{H}_2$  is one product then (0)

1



Ethene shown with double bond +  $\text{Br}_2$  (1)

product (1)

2

(ii) 1,2 (-) dibromoethane only – mark independently of (i)

IGNORE punctuation

1

QWC (c) Ethene has a  $\pi$  / double bond (1)

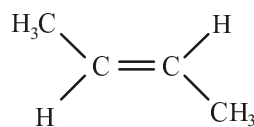
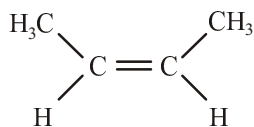
Ethane has  $\sigma$  only / single only / no  $\pi$  / no double bond (1)

$\pi$  (in ethene) weaker than C–H (in ethane) / high electron density in C=C relative to C–H bond (1)

3

[8]

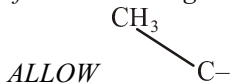
13. (a) (i)



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



2

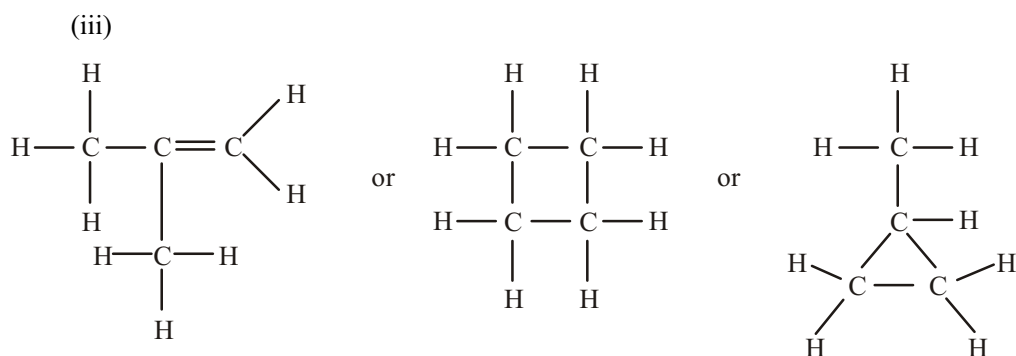
(ii) (Both have) no/restricted rotation about C=C (rotation would require  $\pi$  bond to break) (1)

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

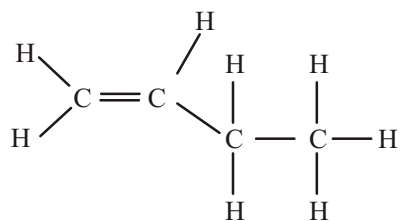
but-2-ene does not (1)

OR other way round

3



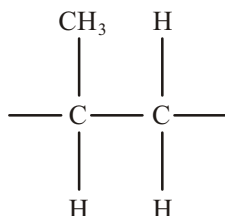
ALLOW



*Do not need to show all bonds eg can be  $-\text{CH}_3$ ,  $-\text{C}_2\text{H}_5$*

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)*

*2<sup>nd</sup> mark consequential on 1<sup>st</sup>*

*NOT "Do not decompose/decay" for 1<sup>st</sup> mark but allow 2<sup>nd</sup> mark*

2

**[10]**

14. (a) Alkene

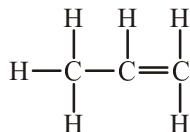
1

- (b)  $\text{CH}_2=\text{CHCH}_2\text{CH}_3$  /  $\text{CH}_3\text{CH}=\text{CHCH}_3$  /  $\text{CH}_2=\text{C}(\text{CH}_3)_2$  /  $\text{CH}_2=\text{C}(\text{CH}_3)\text{CH}_3$   
 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

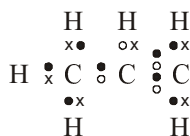
[2]

15. (i)



1

(ii)



ALLOW all dots or crosses

ALLOW TE for a butene/pentene in (a)(i)

IGNORE circle

1

[2]

16.  $(\text{CH}_3)_2\text{C}=\text{CH}_2$

ALLOW displayed formula (1)

ALLOW  $\text{C}(\text{CH}_3)_2=\text{CH}_2$

$\text{CH}_3\text{C}(\text{CH}_3)=\text{CH}_2$

$\text{CH}_3\text{CCH}_3=\text{CH}_2$

$\text{CCH}_3\text{CH}_3=\text{CH}_2$

$\text{CH}_3\text{CH}_3\text{C}=\text{CH}_2$

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

(2-)methylpropene

2 - methylprop - 1 - ene

2 - methylprop - 2 - ene

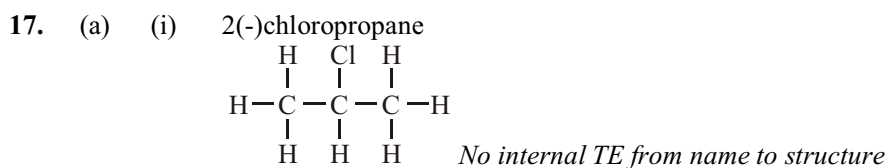
}  
 } IGNORE punctuation, spaces etc  
 }

Mark independently

No transferred error allowed

2

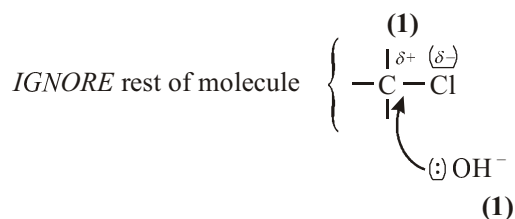
[2]



*MUST be fully displayed*

2

(ii)

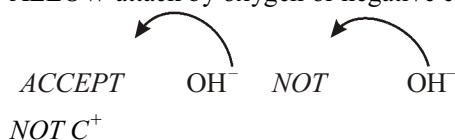


Mark independently

Must attack the carbon

ALLOW attack by oxygen or negative charge or lone pair

2



(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 1<sup>st</sup> mark*

Alcoholic solution / ethanolic solution **and** heat / warm / reflux (1)

2<sup>nd</sup> mark is dependent on mention of correct reagent or “alkali”

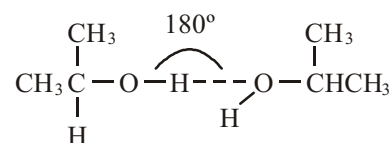
“aqueous” negates 2<sup>nd</sup> mark eg KOH(aq) + heat (1) – ie reagent mark  
NaOH(alc) + heat (2)

2

(c) (i) Hydrogen/H bonding

1

(ii)



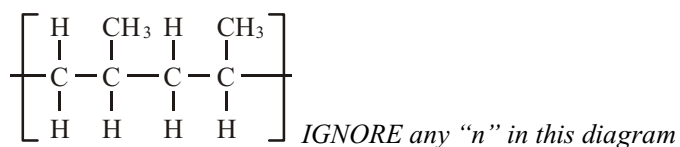
*H-bond and rest of molecule (1)*

*angle must be between 3 atoms for a correct H bond (1)*

*ALLOW HOH 106-108°*

2

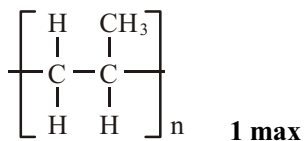
(d) (i)



Brackets optional but continuation must be shown

4 carbon chain with 6Cs overall in structure (1)

methyl groups can be on C<sub>1</sub> and C<sub>3</sub>, C<sub>1</sub> and C<sub>4</sub>, C<sub>2</sub> and C<sub>4</sub>, C<sub>2</sub> and C<sub>3</sub> (1)



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-1,3-diene)  
~~M P P m P P H N M P m P N~~  
 (1) (1)

IGNORE punctuation

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

2

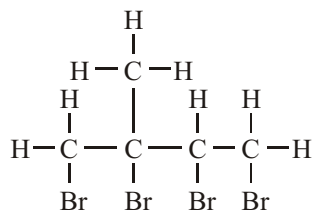
(ii) From orange/yellow/brown to colourless (1)  
 NOT red NOT clear

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)

2<sup>nd</sup> mark dependent on 1<sup>st</sup>

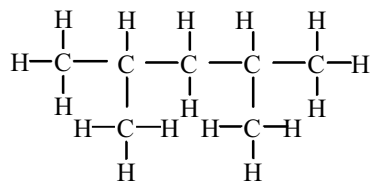
Incorrect isomer chosen (0)

Fully correct reverse argument (2)

2

[9]

19. (a) (i)

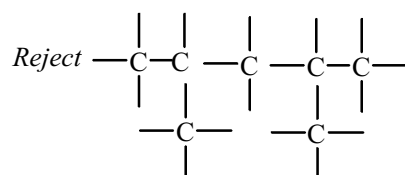
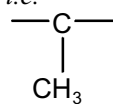


1

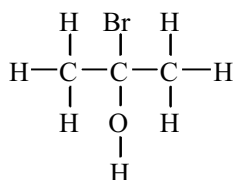
Accept CH<sub>3</sub> in branches

But do not allow bond directly to H

i.e.

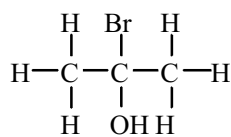


(ii)



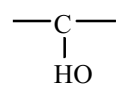
1

Accept

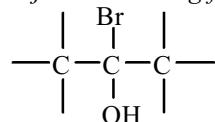


Reject bond pointing directly to H i.e.

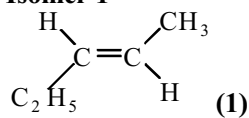
in OH i.e.



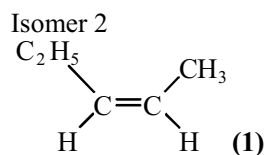
Reject Hs missing from carbons i.e.



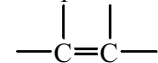
(b) Isomer 1



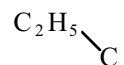
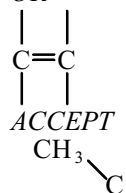
(1)



Accept 90° bond angles e.g



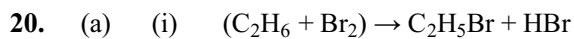
OR



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

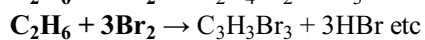
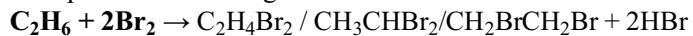
2

[4]



OR

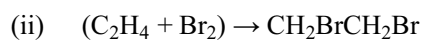
multiple substitution e.g.



1

Accept  $\text{CH}_3\text{C H}_2\text{Br}$  or full structural formula

Reject  $\text{C}_2\text{H}_6 + 3\text{Br}_2 \rightarrow 2\text{C} + 6\text{HBr}$



1

Reject  $\text{C}_2\text{H}_4\text{Br}_2$

- (b) (i) ethane C–H bond **and** ethene C=C bond (1)  
 ALLOW carbon–carbon if double in type of bond  
 ethane type:  $\sigma$ /sigma **and** ethene type:  $\pi$ /pi (1)  
 OR mark horizontally

2

Reject  $\sigma$  and  $\pi$  for ethene

(ii)  $\pi$ /pi bond is weaker (than the  $\sigma$ /sigma bond) 1

*Accept  $\pi$ /pi bond requires less energy to break*

*OR*

*$\pi$ /pi bond has lower bond enthalpy*

*Reject  $\pi$  breaks more easily*

*Reject  $\pi$  bond is weak*

*OR*

*$\pi$ /pi bond has higher electron density (than the  $\sigma$ /sigma bond)*

*Accept  $\pi$ /pi bond has more accessible electron density*

[5]

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

*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<sub>2</sub> 17/2 can be written 8.5 or 8½*  
*Allow balanced equations based on C<sub>8</sub>H<sub>18</sub> with a smaller alkane in the products for 1 mark eg*  
 $C_8H_{18} + O_2 \rightarrow CO + C_7H_{16} + H_2O$  (1)

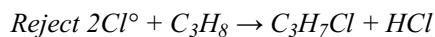
- (b) (i) Increase in pressure: No effect as number of moles/molecules (of gas) doesn't change during reaction (1)  
 Increase in temperature: **more NO** as forward reaction endothermic OWTTE (1)  
 One mark for two correct predictions with incorrect explanations 2  
*Reject increase in temperature moves equilibrium to the right*
- (ii) Rate increases as converter gets hotter (as reaction is exothermic) 1
- (iii) N<sub>2</sub> / nitrogen is (major) part of air/ N<sub>2</sub> 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<sub>A</sub> (1)  
 Curve of similar shape above existing curve, starting and finishing at same levels, with maximum above original maximum (1) 2

[12]

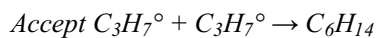
22. (a) (i) A and/or propene 1  
*Accept prop-1-ene*  
*Reject A and any other letter*

- (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-bromopropane 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)  $\text{Cl}_2 \rightarrow 2\text{Cl}^\bullet$   
 Ignore state symbols 1  
*Reject not 2 Cl(g)*  
*Reject  $\text{Cl}_2 \rightarrow 2\text{Cl}$*

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



- (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 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*

$$\text{Amount of } H_2O = \frac{0.020}{18}$$

= 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 1<sup>st</sup> 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))*

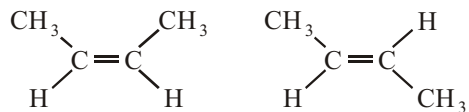
- (iii) (0.01 mol **Z** contain  $\frac{20.0 \times 1.00}{1000} = 0.02$  (mol) **(1)**  
 Accept formula alone for **Z**
- CO<sub>2</sub>H  
 |  
 CO<sub>2</sub>H **(1)** 2  
 Accept fully/partially displayed formula
- (iv) **W** CH<sub>2</sub>=CH<sub>2</sub> **(1)**  
**X** CH<sub>2</sub>BrCH<sub>2</sub>Br **(1)**  
**Y** CH<sub>2</sub>OHCH<sub>2</sub>OH **(1)**  
 Look out for TE and internal TE  
 Eg **W** CH<sub>3</sub>CHCH<sub>2</sub>  
**X** CH<sub>3</sub>CHBrCH<sub>3</sub>  
**Y** CH<sub>3</sub>CHOHCH<sub>3</sub>  
 is worth **1 max** 3  
 Accept full credit for consistent answers based on other gaseous alkenes eg CH<sub>3</sub>CHOHCH<sub>2</sub>OH etc
- (v) C<sub>20</sub>H<sub>42</sub> → C<sub>18</sub>H<sub>38</sub> + C<sub>2</sub>H<sub>4</sub> **(1)**  
 Allow C<sub>17</sub>H<sub>36</sub> + C<sub>3</sub>H<sub>6</sub> OR C<sub>16</sub>H<sub>34</sub> + C<sub>4</sub>H<sub>8</sub> 1  
 Accept TE for **W**  
 Accept any balanced equation including ethane
- (b) Potassium manganate(VII)/KMnO<sub>4</sub> **(1)**  
 Sulphuric acid/H<sub>2</sub>SO<sub>4</sub> 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<sub>2</sub>SO<sub>4</sub>/sulphuric acid  
 2. H<sub>2</sub>O/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)  $\text{CH}_3\text{CHBrCH}_2\text{CH}_3 + \text{KOH} \rightarrow \text{CH}_3\text{CHOHCH}_2\text{CH}_3 + \text{KBr}$   
 OR  
 $\text{CH}_3\text{CHBrCH}_2\text{CH}_3 + \text{OH}^- \rightarrow \text{CH}_3\text{CHOHCH}_2\text{CH}_3 + \text{Br}^-$  1
- Accept C<sub>2</sub>H<sub>5</sub> instead of CH<sub>2</sub>CH<sub>3</sub>*  
*Allow K<sup>+</sup> as spectator ion*  
*Reject eqns with NaOH*
- (iii) water / H<sub>2</sub>O / aqueous ethanol 1
- Accept C<sub>2</sub>H<sub>5</sub>OH (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)  $\text{CH}_3\text{CHBrCH}_2\text{CH}_3 + \text{OH}^- \rightarrow \text{CH}_3\text{CH}=\text{CHCH}_3 + \text{H}_2\text{O} + \text{Br}^-$   
 OR  
 $\text{CH}_3\text{CHBrCH}_2\text{CH}_3 + \text{OH}^- \rightarrow \text{CH}_2=\text{CHCH}_2\text{CH}_3 + \text{H}_2\text{O} + \text{Br}^-$   
 Double bond need not be shown 1
- Accept C<sub>2</sub>H<sub>5</sub> instead of CH<sub>2</sub>CH<sub>3</sub>*  
*Ignore spectator ions*
- (ii) Ethanol / C<sub>2</sub>H<sub>5</sub>OH / CH<sub>3</sub>CH<sub>2</sub>OH /
- $$\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{H}-\text{C}-\text{C}-\text{OH} \\ | \quad | \\ \text{H} \quad \text{H} \end{array}$$
- 1
- Accept alcohol OR Ethanolic/alcoholic*  
*Accept KOH/NaOH*  
*Reject C<sub>2</sub>H<sub>6</sub>O*  
*Reject any mention of water/aqueous*
- (iii) elimination  
 ignore "nucleophilic" 1
- Reject electrophilic elimination*

(c) (i) 1



*bond to H of CH<sub>3</sub> 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<sub>3</sub> 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<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub> 1

*C<sub>2</sub>H<sub>5</sub> for CH<sub>3</sub>CH<sub>2</sub>*

*JUST "C<sub>4</sub>H<sub>10</sub>"*

[12]

25. (a) (i) (Concentrated) sulphuric acid/H<sub>2</sub>SO<sub>4</sub> (1)  
Water/H<sub>2</sub>O (1)  
Any order 2

*Accept phosphoric acid  
1 HBr 2 NaOH/KOH (2)  
H<sub>2</sub>SO<sub>4</sub> + NaOH/KOH (1 max)  
H<sub>2</sub>O and high T and P and catalyst (1 max)*

*Reject dilute/aq sulphuric acid  
H<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> (0)  
H<sub>2</sub>O alone (0)  
H<sub>2</sub>O + × (eg H<sub>2</sub>O<sub>2</sub>) (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 1
- Ignore (aq)
- Accept KBr + H<sub>2</sub>SO<sub>4</sub>/H<sub>3</sub>PO<sub>4</sub>*  
*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) electrons (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)  $\text{Br}^{\delta+} - \text{Br}^{\delta-} / \text{Br}^{\delta+}$  1
- Accept Br<sup>+</sup>*  
*Be generous on symbols for delta*  
*Reject Br<sub>2</sub>*

- (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/ $\text{CH}_3 \text{CH}_2 \text{CH}_2 \text{CH}_3$  1  
*Accept displayed formulae*  
*Accept  $\text{C}_2\text{H}_5$  instead of  $\text{CH}_3 \text{CH}_2$*   
*Reject  $\text{C}_4\text{H}_{10}$*
- (ii) Hydrogen **(1)**  
 Nickel **(1)** 2  
*Accept  $\text{H}_2$*   
*Accept Ni*  
*Accept platinum/Pt or palladium/Pd*  
*Reject H*
- (iii) Chlorine **(1)**  
 UV/ultraviolet/sunlight **(1)** 2  
*Accept  $\text{Cl}_2$*   
*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<sub>2</sub>
  - (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) alkene(s) 1
- Reject C=C*  
*Reject alkane*
- (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

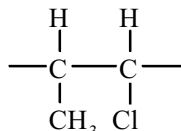
therefore lower activation energy/ $E_{\text{act}}$  (1)

[Lower  $E_{\text{act}}$  must be related to C-X bond]

3

*Accept reverse argument*

(d)

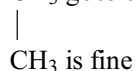


2 carbon chain with continuation bonds in repeat unit (1)

All other atoms correct (1)

IGNORE subscript n

IGNORE where the bond to the CH<sub>3</sub> goes e.g.



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 2<sup>nd</sup> 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]

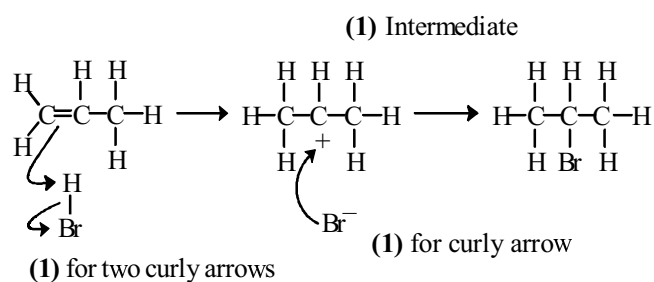
28. (a) A 1  
 (b) C 1

[2]

29. B [1]

30. C [1]

31. (a) (i)

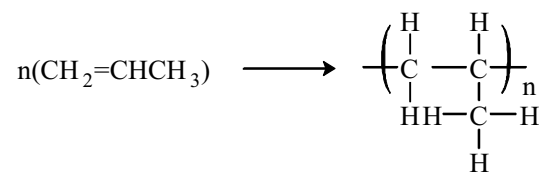


3

*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 /  $KMnO_4(aq)$  1

(c)



balanced and double bond broken (1)

CH<sub>3</sub> on side chain (1)

2

*Reject CH<sub>3</sub> in unbranched chain*

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

(e) (i) propagation 1

(ii) C<sub>6</sub>H<sub>14</sub> / hexane /  
Structural, displayed or skeletal formulae of hexane 1

**[11]**