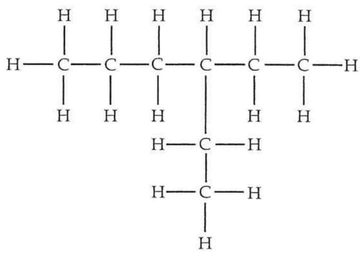
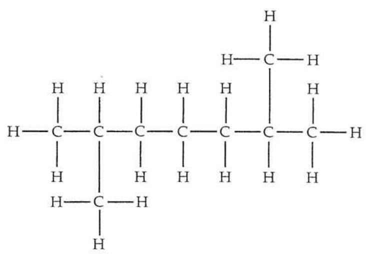
Chapter 4.
Organic Chemistry

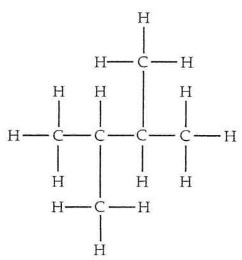
Set 1 Nomenclature

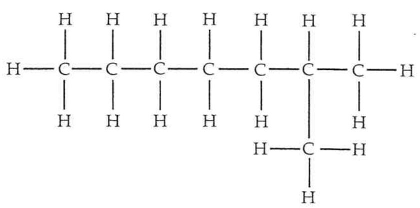
1.
(a) *butane, saturated*
(b) *but-1-ene, unsaturated*
(c) *3-methylpentane, saturated*
(d) *3,4-dimethylhept-3-ene, unsaturated*

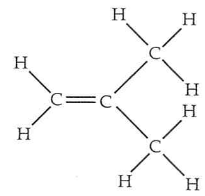
2.
(a) $CH_3CH_2CH_2CH(CH_3)CH_2CH(CH_3)CH_3$
2,4-dimethylheptane
(b) $CH_3CH_2C(CH_3)_2CH_2CH_2CH_3$
3,3-dimethylhexane
(c) $CH_2CHC(CH_3)_2CH_3$
3,3-dimethylbut-1-ene
(d) $CH_3CH(CH_3)CH_2CH_2CH_2CH_2CH(CH_3)CH_3$
2,7-dimethyloctane

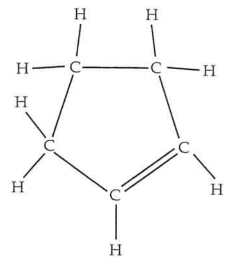
3.
(a)

3-ethylhexane

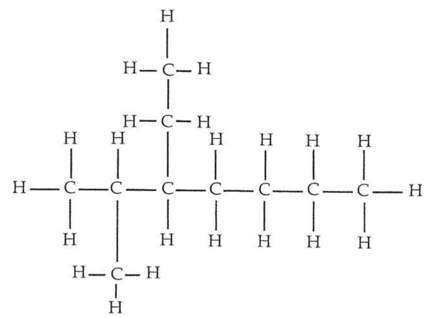
(b)

2,6-dimethylheptane

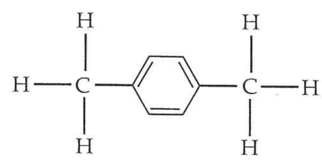
(c)

2,3-dimethylbutane

(d)

2-methylheptane

4.
(a)

aliphatic

(b)

alicyclic

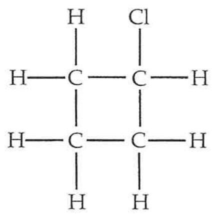
(c)

aliphatic

(d)

aromatic

5.
(a) *alcohol* — *butan-1-ol*
(b) *alkene* — *hex-3-ene*
(c) *alkane* — *4-ethyl-2-methylheptane*
(d) *halogenoalkane* — *5,6-dibromo-1-chlorooctane*
(e) *aldehyde* — *pentanal*
(f) *alcohol* — *pentan-3-ol*
(g) *ketone* — *hexan-3-one*
(h) *carboxylic acid* — *pentanoic acid*
(i) *amine* — *butanamine*
(j) *ester* — *propylpropanoate*
(k) *amide* — *butanamide*
(l) *amino acid* — *2-aminobutanoic acid*
(m) *carboxylic acid* — *3,3-dimethylhexanoic acid*
(n) *alkene* — *1-chlorohex-3-ene*
(o) *amine* — *3-chloro-2-methylbutanamine*
(p) *ester* — *pentylbutanoate*
(q) *ketone (alcohol)* — *6-hydroxyhexan-3-one*
(r) *ester* — *ethylpropanoate*

(s) *amide* *5-chloro-4-methylpentanamide*
(t) *alcohol* *octan-2,6-diol*
(u) *aldehyde* *4-bromobutanal*
(v) *amine* *3,6-octandiamine*
(w) *carboxylic acid (-ol)* *4-hydroxybutanoic acid*

6.
(a) $CH_3CH(OH)CH_2CH_3$
(b) $CH_3CHICl_2CH_2CH_3$
(c) CH_3CH_2CHO
(d) $CH_3CH(OH)C(CH_3)_2CH_2CH_2CH_3$
(e) $CH_3CH_2CH_2COOH$
(f) $CH_3(CH_2)_4NH_2$
(g) $CH_3(CH_2)_3CH(OH)CH_2COOH$
(h) $CH_3CH_2COCH_2CH_3$
(i) $CH_3CH_2CH(NH_2)CH_2CH_2COOH$
(j) $CH_3(CH_2)_2CONH_2$
(k) $CH_3CHCHCHCClCHClCH_3$
(l) $CH_3COCH_2CH_2COOH$

7.
(a)


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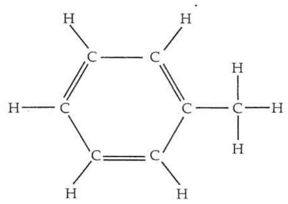
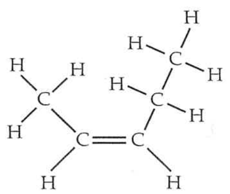


(c)


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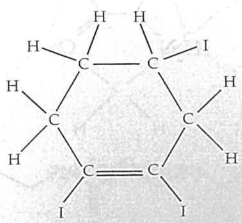

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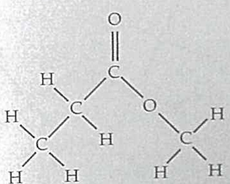

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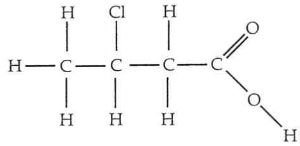
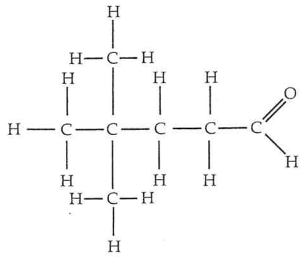
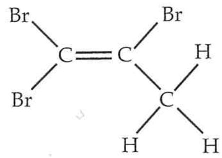
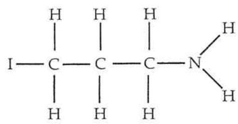


(g)


(h)


(i)


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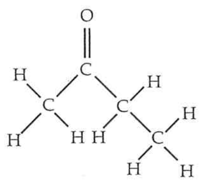

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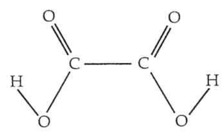

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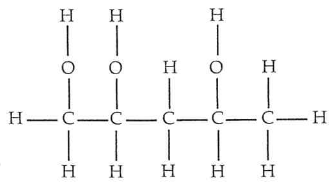

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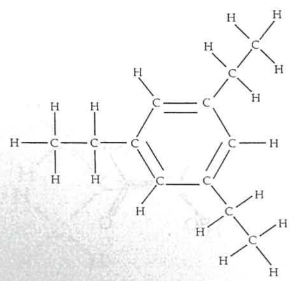

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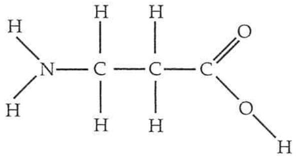
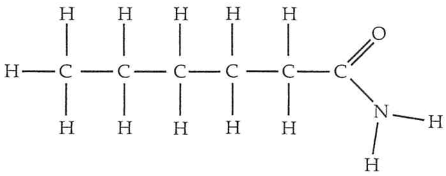
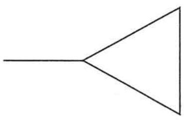


(o)

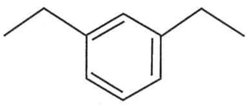


8.
(a) *cyclopentane*
(b) *1-bromo-3-chlorocyclopentane*
(c) *4-ethyl-5-methyloctane*
(d) *trans hexa-1,4-diene*
(e) *1,4-diethylbenzene*
(f) *cis-2-pentene*
(g) *1,3-diiodocyclohexene*

9.
(a)

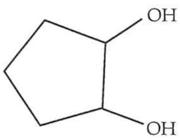


(b)



(c)

(d)



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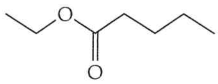
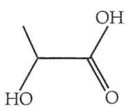
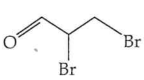


(f)



(g)



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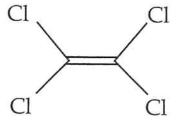
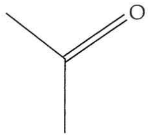
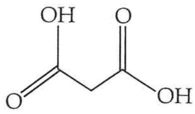


(i)

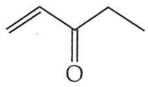
(j)



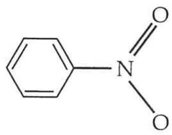
(k)



(l)



(m)



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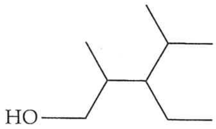
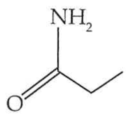
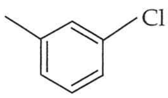


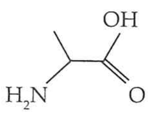
(o)



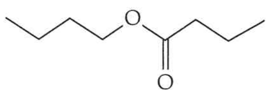
(p)



(q)

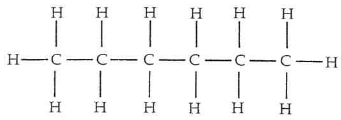


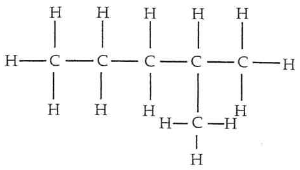
(r)

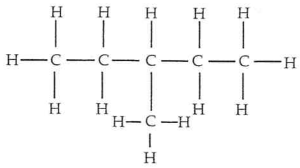


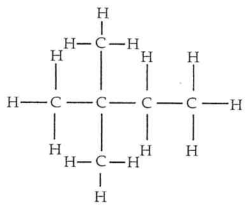
Set 2 Isomers

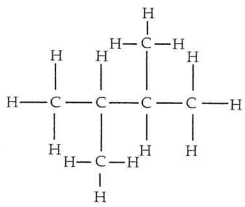
1.



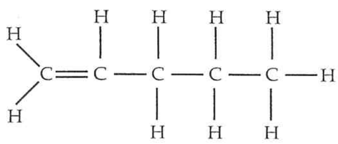




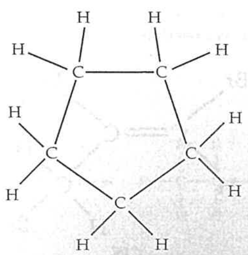




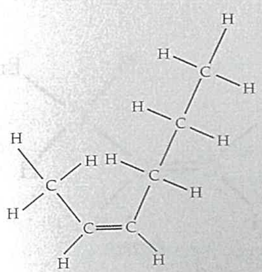
2.



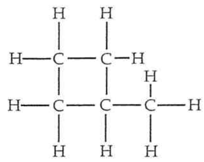
pent-1-ene



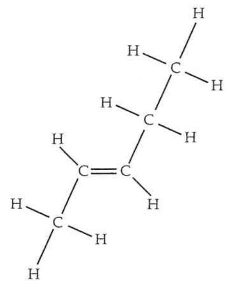
cyclopentane



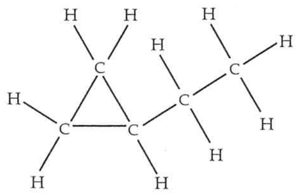
cis pent-2-ene



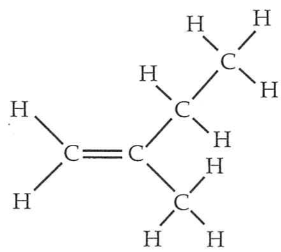
methylcyclobutane



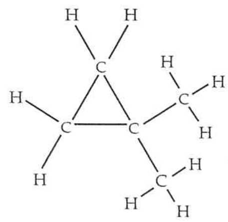
trans-pent-2-ene



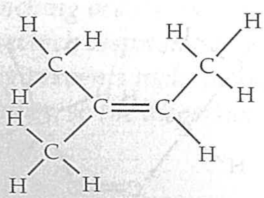
ethylcyclopropane



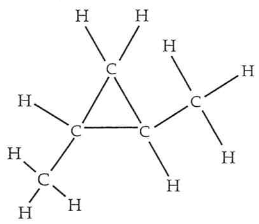
2-methylbut-1-ene



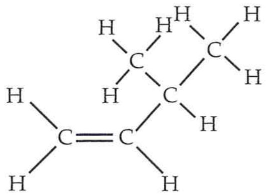
1,1-dimethylcyclopropane



2-methylbut-2-ene

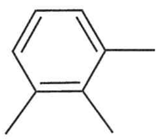


1,2-dimethylcyclopropane

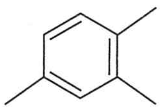


3-methylbut-1-ene

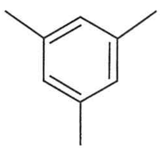
3.



1,2,3-trimethylbenzene



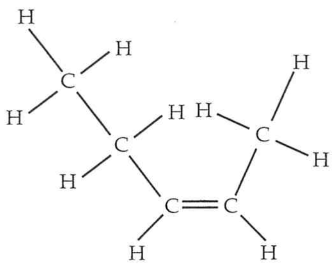
1,2,4-trimethylbenzene



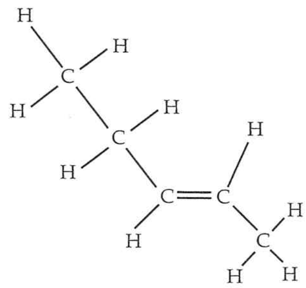
1,3,5-trimethylbenzene

4.

(a) *pent-2-ene*

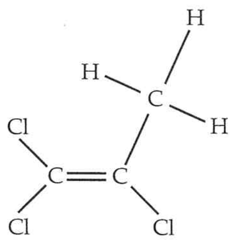


cis



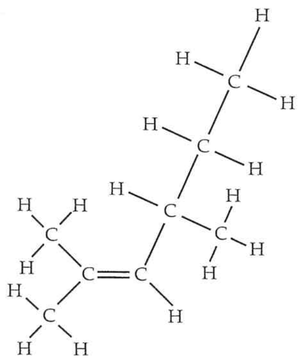
trans

(b) *1,1,2-trichlorobut-1-ene*



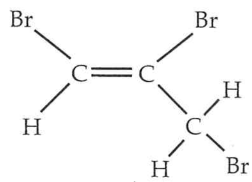
No cis or trans

(c) *2,4-dimethylhex-2-ene*

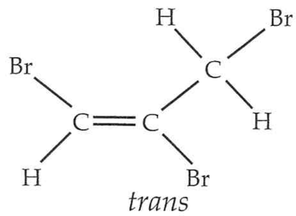


No cis or trans

(d) *1,2,3-tribromopropene*

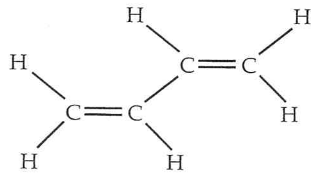


cis



trans

(e) *1,3-butadiene*



No cis or trans

Set 3 Reactions and Properties of the Aliphatic Hydrocarbons

1.

(a)

i) $CH_2CHCH_2CH_3 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

ii) $2CH_3CH(CH_3)CH_3 + 13O_2 \rightarrow 8CO_2 + 10H_2O$

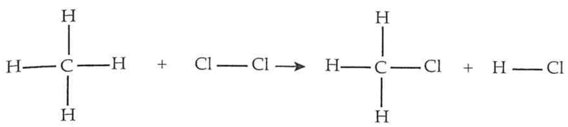
(b)

i) $2CH_3(CH_2)_3CH_3 + 11O_2 \rightarrow 10CO + 12H_2O$

ii) $C_6H_{12} + 6O_2 \rightarrow 6CO + 6H_2O$

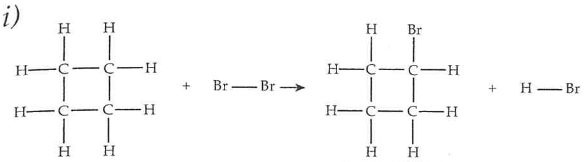
2.

(a)



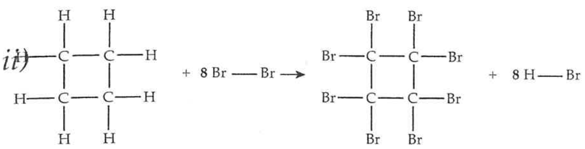
(b)

i)



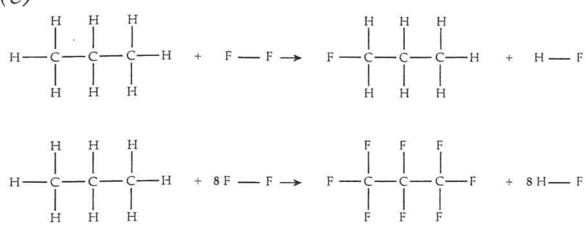
bromocyclobutane

ii)



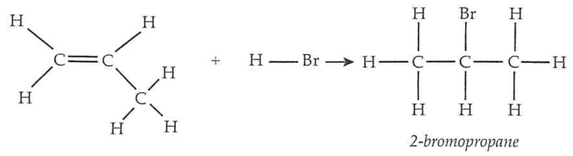
octabromocyclobutane

(c)



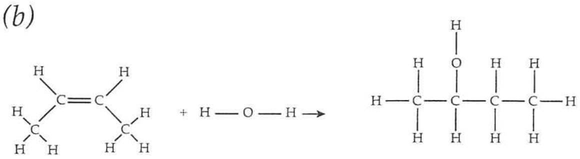
3.

(a)



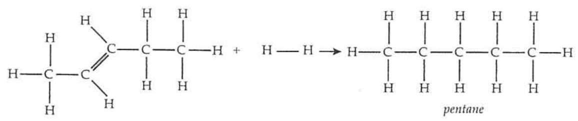
2-bromopropane

(b)



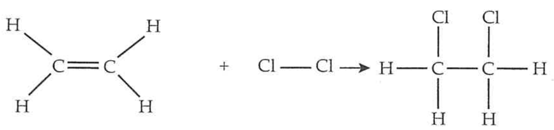
butan-2-ol

(c)



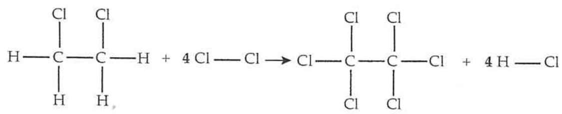
pentane

(d)



1,2-dichloroethane

and then...



hexachloroethane

4.

(a) *2-chloropropane*

(b) *2-chloro-2-methylbutane*

(c) *2,2-dichloropropane*

Properties

5. *To boil each of these alkanes requires dispersion forces only to be broken. As more branching occurs there is less surface area over which dispersion forces can act. Branching prevents molecules from getting close together, so the dispersion forces are less effective.*

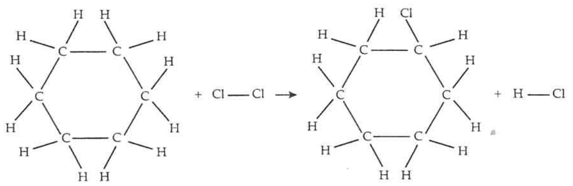
6. *Tetrachloroethene is a non-polar molecule with dispersion forces between molecules. For it to be readily soluble in water, the intermolecular forces that form between it and water would have to be equal to or*

stronger than the intermolecular forces of both it and water. Since the strongest bonds that can form between tetrachloroethene and water are dispersion forces these aren't strong enough to overcome the hydrogen bonding between water molecules to any reasonable extent. Trichloroethene is a polar molecule with dipole-dipole interactions between molecules. It can form dipole-dipole interactions with water and as such can overcome the bonding between water molecules to a much larger extent.

Set 4 Reactions of the Alicyclic and Aromatic Hydrocarbons

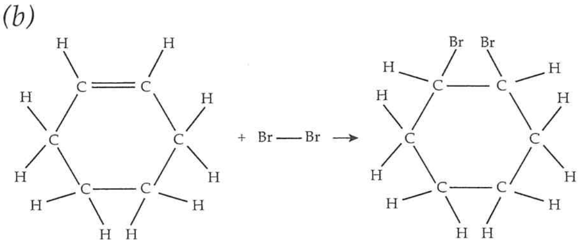
1.

(a)



chlorocyclopentane

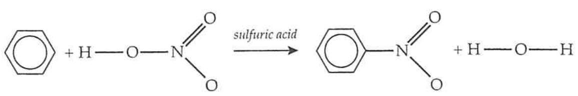
(b)



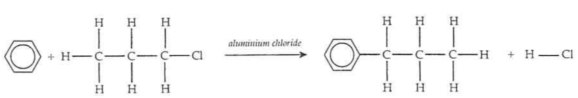
1,2-dibromocyclohexane

2.

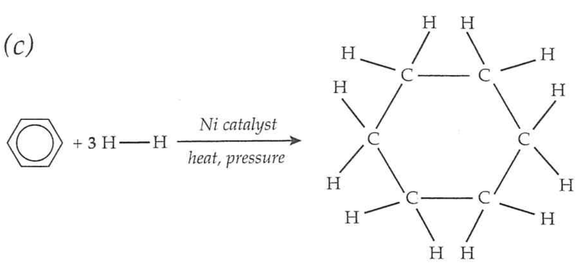
(a)



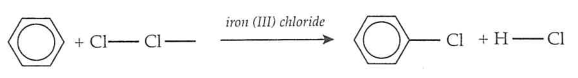
(b)



(c)



(d)



Set 5 Reactions and Properties of Alcohols

1.

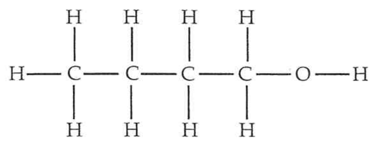
(a) 1,1-dimethylpropan-1-ol; a tertiary alcohol

(b) butan-1-ol; a primary alcohol

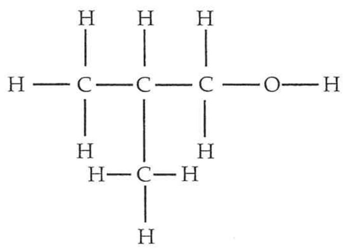
(c) 1,5-dimethylhexan-1-ol; a secondary alcohol

(d) pentan-3-ol; a secondary alcohol

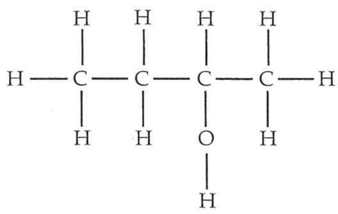
2.



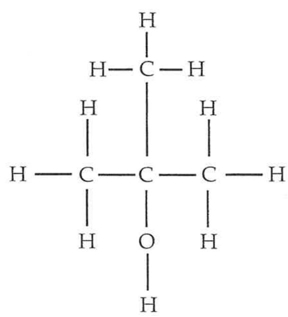
butan-1-ol



2-methylpropan-1-ol



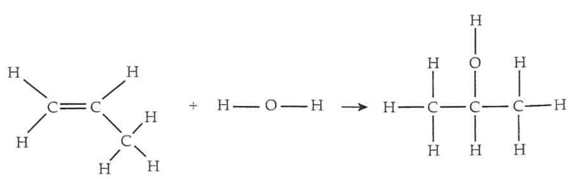
butan-2-ol



2-methylpropan-2-ol

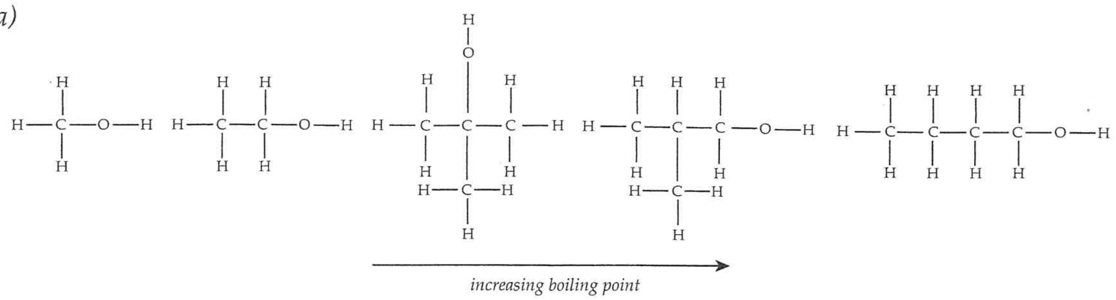
3. $2CH_3CHOHCH_3 + 9O_2 \rightarrow 6CO_2 + 8H_2O$

4.



propane *water* *propan-2-ol*

7. (a)



5.

Reduction half equation	$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
Oxidation half equation	$CH_3CHOHCH_2CH_3 \rightarrow CH_3COCH_2CH_3 + 2H^+ + 2e^-$ (x3)
Overall equation	$Cr_2O_7^{2-} + 8H^+ + 3CH_3CHOHCH_2CH_3 \rightarrow 2Cr^{3+} + 7H_2O + 3CH_3COCH_2CH_3$
Names	chromium ions, water and butan-2-one

6.

Reduction half equation	$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ (x 4)
Oxidation half equation	$CH_3(CH_2)_4OH + H_2O \rightarrow CH_3(CH_2)_3COOH + 4H^+ + 4e^-$ (x 5)
Overall equation	$4MnO_4^- + 5CH_3(CH_2)_4OH + 12H^+ \rightarrow 4Mn^{2+} + 5CH_3(CH_2)_3COOH + 11H_2O$
Names	manganese ions, water and pentanoic acid

7.
(a) *(see above).*
(b) *All of these substances have hydrogen bonding so you cannot use this directly to rank them in boiling point order. They will all have dispersion forces, which increase with increasing molar mass so methanol and ethanol are easy to place in order. Methylpropan-1-ol, methylpropan-2-ol and butanol all have the same molar mass. We must therefore look at how the branching affects dispersion forces and also the accessibility of the -OH for hydrogen bonding. Methylpropan-1-ol and methylpropan-2-ol are branched so butanol can be placed above these due to increased surface area for dispersion forces. The –OH on methylpropan-1-ol is more accessible for hydrogen bonding so it can be placed above methlypropan-2-ol.*

8. $2Na + 2CH_3CH_2CH_2OH \rightarrow 2CH_3CH_2CH_2ONa + H_2$

9. *Add orange acidified potassium permanganate to the alcohol. If it is a secondary alcohol it will be oxidised to a ketone and the solution will become green. If it is a tertiary alcohol it will remain orange as no oxidation takes place.*

10.
(a) *3-methylbutan-2-ol*
(b) *4,4-dimethylhexan-2-ol*
(c) *2-methylpentan-3-ol*
(d) *cyclohexanol*

Set 6 Aldehydes, Ketones, Carboxylic Acids and Esters

1.
(a) *ketone*
(b) *ester*
(c) *aldehyde*
(d) *carboxylic acid*
(e) *ketone*
(f) *ester*
(g) *oxocarboxylic acid*

2.
(a) *butanone*
(b) *propylbutanoate*
(c) *butanal*
(d) *hexanoic acid*
(e) *octan-2-one*
(f) *ethylpropanoate*
(g) *5-oxohexanoic acid*

3. $2CH_3COCH_3 + 8O_2 \rightarrow 6CO_2 + 6H_2O$

4. $CH_3CH_2CH_2COOH + 3O_2 \rightarrow 4CO + 4H_2O$

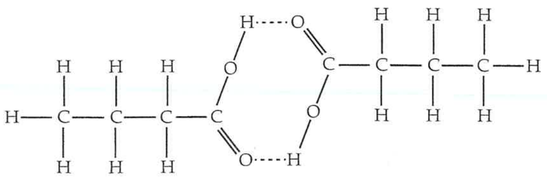
5.

Reduction half equation	$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ (x 2)
Oxidation half equation	$CH_3CH_2CH_2CH_2OH \rightarrow CH_3CH_2CH_2CHO + 2H^+ + 2e^-$ (x 5)
Overall equation	$2MnO_4^- + 6H^+ + 5CH_3CH_2CH_2CH_2OH \rightarrow 2Mn^{2+} + 8H_2O + 5CH_3CH_2CH_2CHO$
Names of all species	permanganate ions, hydrogen ions, butan-1-ol, manganese ions, water, butanal

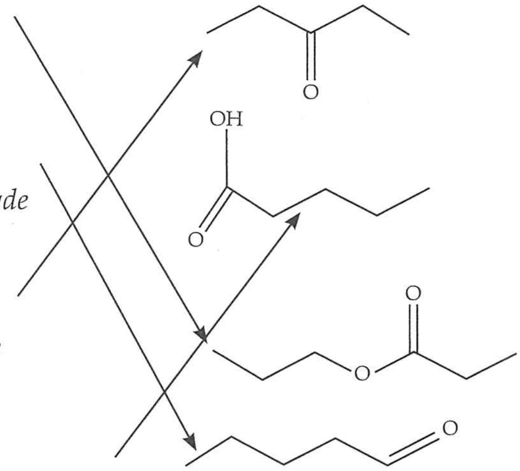
6.

Reduction half equation	$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
Oxidation half equation	$CH_3CH_2CHOHCH_2CH_3 \rightarrow CH_3CH_2COCH_2CH_3 + 2H^+ + 2e^-$ (x 3)
Overall equation	$Cr_2O_7^{2-} + 8H^+ + 3CH_3CH_2CHOHCH_2CH_3 \rightarrow 2Cr^{3+} + 7H_2O + 3CH_3CH_2COCH_2CH_3$
Names of all species	dichromate ions, hydrogen ions, pentan-3-ol, chromium ions, water, pentan-3-one

7. *1-butanol and an oxidising agent like $KMnO_4$ or $K_2Cr_2O_7$*
8. $CH_3CH_2CH_2OH + CH_3CH_2CH_2COOH \rightarrow CH_3CH_2CH_2OOCCH_2CH_2CH_3 + H_2O$
9.
(a) $2CH_3CH_2COOH(aq) + MgCO_3(s) \rightarrow Mg^{2+}(aq) + 2CH_3CH_2COO^-(aq) + H_2O(l) + CO_2(g)$
White solid added to clear, colourless solution. Solid dissolves to produce a clear colourless solution with effervescence of a colourless, odourless gas.
(b) $2CH_3CH_2COOH(aq) + 2Na(s) \rightarrow 2Na^+(s) + 2CH_3CH_2COO^-(aq) + H_2(g)$
Dull grey metallic solid added to clear, colourless solution. Solid dissolves to produce a clear, colourless solution with vigorous effervescence of a colourless, odourless gas.
(c) $CH_3CH_2COOH(aq) + KOH(aq) \rightarrow K^+(aq) + CH_3CH_2COO^-(aq) + H_2O(l)$
or ionic equation
$CH_3CH_2COOH(aq) + OH^-(aq) \rightarrow CH_3CH_2COO^-(aq) + H_2O(l)$
Clear, colourless solution added to clear, colourless solution. No visible reaction.
(d) $CH_3CH_2COOH + CH_3CH_2OH \rightarrow CH_3CH_2COOCH_2CH_3 + H_2O$
Clear, colourless solution added to a clear, colourless liquid. Two clear colourless immiscible layers are produced. The top layer has a fruity, sweet odour.
(e) $CH_3CH_2COOH(aq) + 2K^+(aq) + Cr_2O_7^{2-}(aq) \rightarrow NR$
An orange solution is added to a clear, colourless solution. The resulting solution remains orange.
10. *butane, butanal, butan-1-ol, butanoic acid. Butane is non-polar and has weak dispersion forces. Butanal is a polar molecule and has stronger dipole-dipole intermolecular forces. 1-butanol and butanoic acid are polar and both have the strongest intermolecular forces, hydrogen bonding, between their molecules. Butanoic acid has the ability to form more hydrogen bonds per molecule (and also a dimer shown below where two molecules hydrogen bond with each other giving greater dispersion forces).*



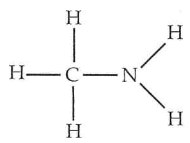
11.
ester
aldehyde
ketone
carboxylic acid



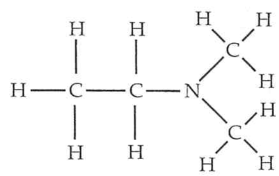
Set 7 Amines, Amides and Amino Acids

1.
(a) *amide; 3-methylbutanamide*
(b) *amine; butan-2-amine*
(c) *amine; octan-1-amine*
(d) *amino acid; 2-aminopropanoic acid*
(e) *amide; pentanamide*
(f) *amino acid; 3-aminopropanoic acid*

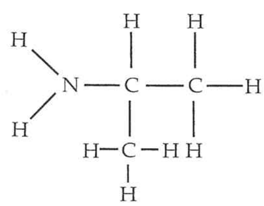
2.
(a) *primary*



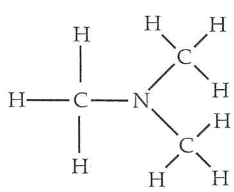
(b) *tertiary*



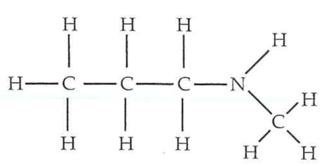
(c) *primary*



(d) *tertiary*



(e) *secondary*



3.

(a) *butanamide*

(b) *4-aminobutan-2-ol*

(c) *2-aminoheptanoic acid*

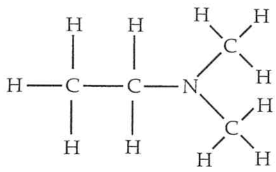
(d) *pentanamide*

(e) *hexanamine*

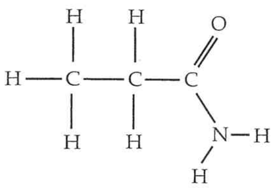
(f) *2-aminobenzoic acid*

4.

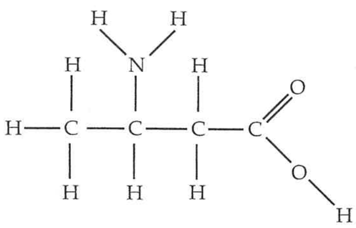
(a)



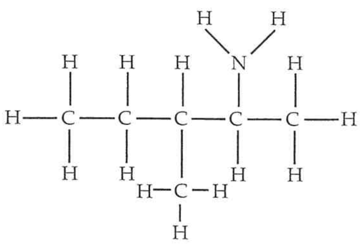
(b)



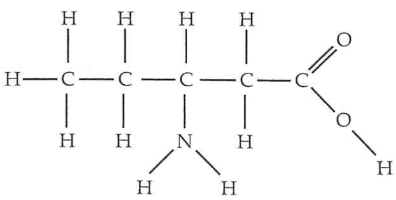
(c)



(d)



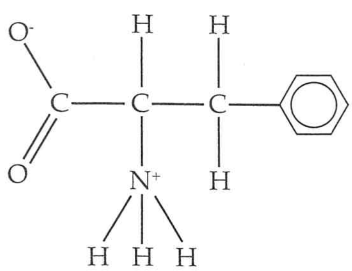
(e)



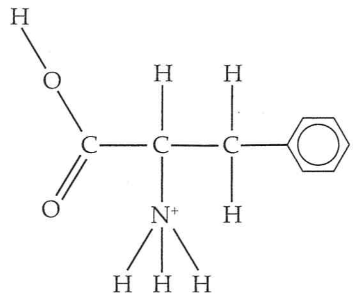
5. *a, b and e are α-amino acids.*

6.

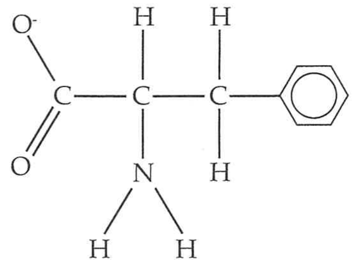
(a)



(b)



(c)

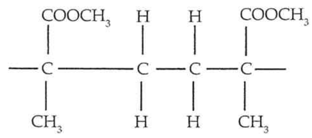


Set 8 Polymers and Amino Acids

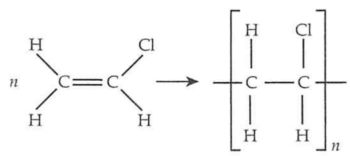
1.

(a) *Perspex is an addition polymer.*

(b)



2.



3. *The PVC chain contains polar carbon to chlorine bonds which can form dipole-dipole interactions with neighbouring chains. These relatively strong intermolecular forces give PVC its strength.*

4.

(a) *(ii)*

(b) *(i)*

(c) *(iii)*

5. *Silks produced by insects are natural protein fibres or polypeptides. They consist of amino acid residues. One such silk was found to consist mainly of alternating glycine and alanine residues.*

(a)