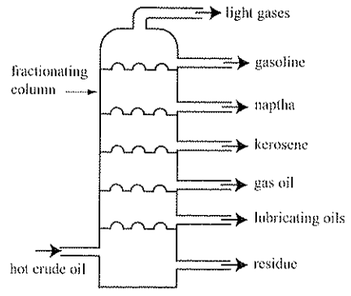
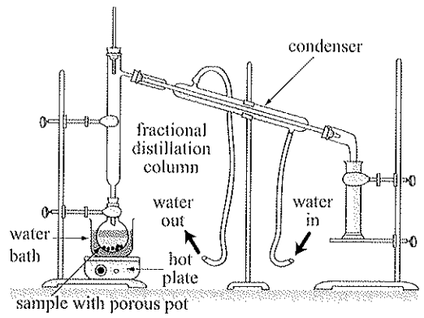
Answers

1 Energy from Fossil Fuels

1. B
2. D
3. B
4. (a) Substance formed from once living things that is now used to produce heat, e.g. coal, petrol.
   (b) Energy source that can be replaced as it is used, e.g. ethanol.
   (c) Compound made of hydrogen and carbon only, e.g. ethane.
   (d) Process of making glucose and oxygen, in green plants, from carbon dioxide and water. Chlorophyll absorbs the sun's energy to make this process occur.
5. (a) Natural gas is a mixture of methane (75–90%), ethane (5–10%), propane and butane (3–6%) and smaller amounts of other alkanes. It may also contain compounds of nitrogen, water vapour, carbon dioxide and traces of hydrogen sulfide.
   (b) Composition can vary; components keep their own properties; no definite melting and boiling point; components can be separated by physical means.
6. solar cells, electrochemical cells, ethanol, wind power
7. Renewable can be replaced, e.g. ethanol.
   Non-renewable cannot be replaced, e.g. coal, petrol, natural gas.
8. (a) fractional distillation
   (b) different boiling points
   (c) gases; petroleum ether; gasoline; kerosene; gas oil; lubrication oil and wax; bitumen (these vary with different sources of oil and conditions of fractional distillation)
   (d) Components can be present in different proportions, keep their own properties and can be separated by physical means.
   (e) (i) Fractionating column



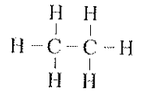
(ii) Fractional distillation

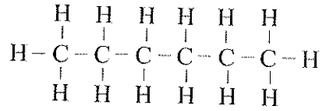


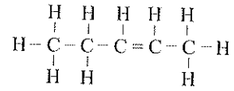
9. (a) non-renewable
   (b) coal, coke, natural gas, crude oil (or petroleum)
   (c) marine organisms
   (d) sun
   (e) photosynthesis
   (f) methane and ethane
   (g) $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

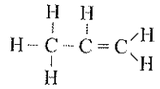
2 Carbon Compounds

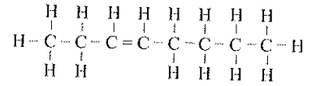
1. A
2. C
3. (a) A group or family of compounds that have similar structures and chemical properties.
   (b) Organic (carbon) compound containing only atoms of carbon and hydrogen.
   (c) Element in Group VII of the periodic table.
   (d) A grouping of atoms that is common to all members of an homologous series and is responsible for its properties.
   (e) Hydrocarbon containing only single bonds, with the general formula C_nH_{2n+2}.
   (f) Bonding involving the sharing of electrons between atoms.
   (g) Carbon compound that contains only single bonds.
4. (a) Period 2, Group 4, atomic number 6.
   (b) 2.4
   (c) valency of 4; ability to form chains, branching and rings; ability to form single, double and triple bonds
   (d) coal, petroleum, natural gas
5. alkanes C_nH_{2n+2}; alkenes C_nH_{2n}; alkynes C_nH_{2n-2}
6. octene
7. both organic compounds
   Saturated: no double or triple carbon-carbon bonds, e.g. ethane.
   Unsaturated: double or triple carbon-carbon bond(s) present, e.g. ethene, ethyne.
8. (a) ethene 

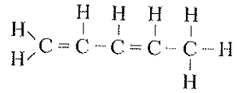
(b) ethane 

(c) hexane 

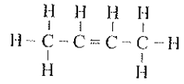
9. Covalent bond formed by shared pair of electrons.
10. (a) pentane
    (b) propyne
    (c) 2-butene
11. (a) Complete: plenty of oxygen available.
    Incomplete: limited supply of oxygen.
    (b) water, carbon dioxide
    (c) Occurs when there is a limited supply of oxygen/incomplete combustion occurs.
12. May be volatile, e.g. petrol — form explosive mixtures with air/oxygen — so no naked flames.
    May be toxic, e.g. methane, so do not ingest or inhale.
    May produce toxic products, e.g. carbon monoxide, during combustion.
13. (a) 2-pentene 

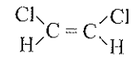
(b) propene 

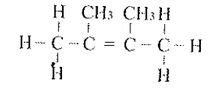
(c) 3-octene 

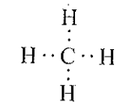
(d) 1,3-pentadiene 

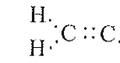
(e) 2-hexene 

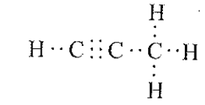
(f) 2-butene 

(g) 1,2-dichloroethene 

(h) 2,3-dimethyl-2-butene 

14. (a) 1-pentene
    (b) 4-methyl-3-octene
    (c) 1-butene
    (d) 2-methyl propene
15. (a) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
    (b) $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$
    (c) $C_2H_4(g) + 2O_2(g) \rightarrow 2CO(g) + 2H_2O(g)$
    (Other correct answers are possible for (c); carbon may be produced or a small proportion of carbon dioxide.)
16. (a) methane 

(b) ethene 

(c) propyne 

17. (a) heptene
    (b) butene
    (c) C_5H_{12}
    (d) homologous series
    (e) functional group
    (f) 6
    (g) 4
    (h) hydrocarbons
    (i) complete
    (j) incomplete
    (k) alkenes
    (l) alkanes
    (m) ethylene
    (n) -ane
    (o) hex-
    (p) double bond between two carbon atoms
    (q) C_nH_{2n+2}
    (r) C_2H_4
    (s) C_2H_6
    (t) alkanes
    (u) – (a dash)
    (v) Group VII

3 Bonding in Carbon Compounds

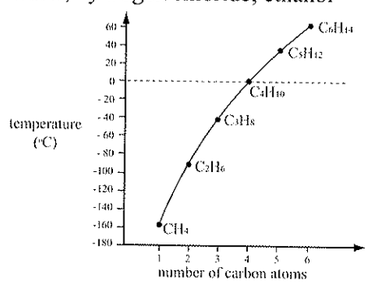
1. Only small intermolecular forces (dispersion forces), so not much energy is needed to pull molecules apart and thus change the state.
2. (a) Attraction between atoms due to the sharing of electrons.
   (b) Covalent bond in which the electron pair is not shared equally so that a dipole forms.
   (c) Covalent bond where electrons are shared equally so there is no dipole formed.
   (d) Strong dipole-dipole force between a hydrogen atom in one molecule and a

fluorine, oxygen or nitrogen atom in another molecule.

(c) Weak attractive force between two molecules due to the temporary attractions between the positive nucleus and negative electron clouds of adjacent molecules as they approach each other.

3. If the polar covalent bonds within the molecule are symmetrically arranged so that they cancel each other out the molecule will have no net dipole so will be non-polar, e.g.

4. Intermolecular. Change of state requires molecules to move faster, breaking the intermolecular bonds so the molecules move more freely. If the bonds are strong, a lot of energy is needed to break them so the melting and boiling points are high.
5. (a) ionic (b) covalent (c) covalent
   (d) ionic (e) covalent (f) ionic
6. (a) water, methane, hydrogen chloride, ethanol, ethane
   (b) water; hydrogen chloride; ethanol
7. (a)



Alkanes – boiling points versus number of carbon atoms

   (b) As the number of carbon atoms in the molecule increases, the boiling point increases.

   (c) Larger molecules have more electrons and thus greater dispersion forces. Greater attractive force means more energy is needed to break the bonds and allow the substance to change state.
8. (a) hydrogen bonds
   (b) dispersion forces
   (c) polar covalent bond
   (d) 4
   (e) within (intramolecular)

4 Ethane and Ethene

1. D
2. C
3. (a) Petroleum — made from chemicals in natural gas and crude oil.

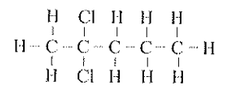
   (b) Very reactive due to double C=C bond.
4. (a) Relatively insoluble in water because no attraction between water and non-polar ethane and ethene molecules.

   (b) Low melting and boiling points because of weak intermolecular forces.

   (c) Alkanes are relatively unreactive because of the single C–C bonds so substitution reactions occur.
   Alkenes have double C=C bond(s) which are more reactive, they undergo addition reactions.
5. (a) Saturated — contains only single C–C bonds.
   Unsaturated — contains double C=C or triple C≡C bonds.

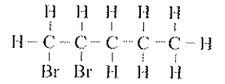
   (b) Add bromine water. If it changes from brown to colourless very quickly then the substance being tested has one or more double or triple bonds.
6. (a) (i) 2-bromopentane
   (ii) 5-bromo-2-pentene

   (b) (i)

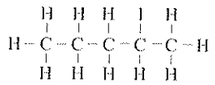


   (ii)

   (iii)

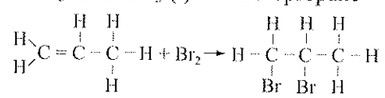


   (iv)

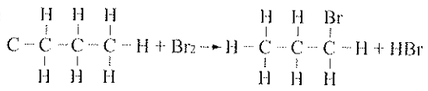


   (v)

7. (a) $C_3H_6(g) + H_2(g) \rightarrow C_3H_8(g)$ propane
   (b) $C_5H_{10}(g) + H_2(g) \rightarrow C_5H_{12}(g)$ pentane
   (c) $C_4H_8(l) + Cl_2(g) \rightarrow$
   $C_4H_8Cl_2(l)$ 1,2-dichlorobutane
   (d) $C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$ ethanol
   (e) $C_3H_6(g) + HCl(g) \rightarrow$
   $CH_3CHClCH_3$ (l) 2- chloropropane
8. (a) (i)



   (ii)

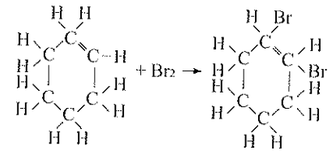


   (b) (i) would be faster; propene is more reactive than propane.

   (c) Allows you to distinguish between compounds that are saturated and those that are unsaturated.
9. Example:
   (a) Place 2 mL cyclohexane in a test tube and 2 mL cyclohexene in another test tube. Add bromine water to the hydrocarbon in each test tube and observe the results.

   (b) The bromine water changed from brown to colourless in the cyclohexene.
   There was no change in the test tube containing cyclohexane.

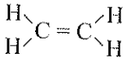
   (c)



   (d) Use fume cupboard; wear protective clothing and goggles to prevent chemicals touching skin or splashing into eyes. Use small amounts.
   Bromine is toxic; it is a skin irritant, producing irritant vapour and it is corrosive. It should be used in a fume cupboard. Student use should be limited to 2 mL of 0.1 mol L^{-1} per activity.
   Cyclohexane and cyclohexane are both toxic, highly flammable and produce toxic vapour. They should be used in a fume cupboard using eye and skin protection.
10. insoluble in water; low melting and boiling points
11. (a) $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$
    (b) $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$
    (c) no reaction
12. Alkanes: single C–C bonds only — undergo substitution reactions.
    Alkenes: double C=C bond(s) — more reactive, undergo addition reactions.
13. (a) ethene
    (b) double bond
    (c) bromine water test
    (d) brown to colourless
    (e) alkene
    (f) addition
    (g) manufacture of industrial solvents, detergents, paints
    (h) petroleum
    (i) ethene
    (j) addition
    (k) substitution
    (l) double C=C bond
    (m) homologous series
    (n) (i) propene
    (ii) butyne
    (iii) pentene

5 Production of Ethene (Ethylene)

1. D
2. B
3. C
4. (a) ethylene
   (b)



   (c) (i) natural gas (ii) petroleum
   (d) Ethylene has a double bond which is more reactive than ethane's single bond.
   (e) garbage bags, foam cups, carpets, rubber bands, snorkels, contact lenses, buttons, plastic flowers, hair spray, shoe soles, insulation, drycleaning fluids, computer discs, artificial flavourings
5. (a) Large molecules are broken into smaller molecules using surface reactions with inorganic catalysts such as alumina-silica gel (zeolites).
   (b) To prevent the combustion of reactants and products.
   (c) Ethene is a raw material for production of most polymers which are used in large quantities.
6. (a) $2C_3H_8(g) \rightarrow 3C_2H_4(g) + 2H_2(g)$
   (b) $C_{16}H_{34} \rightarrow C_8H_{18} + C_8H_{16}$
   (c) $C_6H_{14} \rightarrow 2C_2H_4 + C_2H_6$
7. (a) methane, ethane, propane, butane
   (b) $C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$
   (c) $C(s) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$
   (d) incomplete combustion of carbon compounds
   (e) $2NaOH(aq) + H_2S(g) \rightarrow Na_2S(aq) + 2H_2O(l)$
   $2NaOH(aq) + CO_2(g) \rightarrow$
   $Na_2CO_3(aq) + H_2O(l)$
   (f) $C_2H_2(g) + H_2(g) \rightarrow C_2H_4(g)$
   (g) Of the gas produced, at least 99.85% by weight is pure ethene. It contains a maximun of 0.15% (by weight) impurities.
   (h) 998.5 kg
   (i) ethyne
   (j) Allows gases to be cooled quickly by water.
   (k) Method of separating components of a mixture based on the components having different boiling points. Mixture is heated and the components with lowest boiling point evaporate first. These are extracted and the mixture is then heated to a higher temperature to separate out another fraction.
8. (a) natural gas
   (b) thermal cracking