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About A LEVEL

(PURE) CHEMISTRY

(TOPICAL)

About Thinking Process

When solving problems, we first analyse the questions and then gather relevant information until we are able to determine the answers. But for presentation reason, we need to organise, rearrange and then present ONLY the required workings and solutions.

Thinking process reveals the extra but relevant information which is not required as part of the solutions.

About MCQ with HELPs

Explanations are given so that students know exactly why the answer is the right one.

period	2012 to 2024
contents	June & November, Paper 1 & 2, Worked Solutions
form	Topic By Topic
compiled for	O Levels
special features	Thinking Process, MCQ with HELPs

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Topic 3 *Bonding: The Structure Of Matter*

MCQ Section

1. Four substances have the following electrical properties.

substance	property
W	does not conduct under any conditions
X	conducts only in aqueous solution
Y	conducts in both the molten and solid states
Z	conducts in both the molten and aqueous states

What are these four substances?

	W	X	Y	Z
A	HC*l*	S	NaC*l*	Pb
B	Pb	HC*l*	NaC*l*	S
C	S	HC*l*	Pb	NaC*l*
D	S	NaC*l*	HC*l*	Pb

[J12/P1/Q9]

2. Which substance will conduct electricity without being chemically changed?

A sodium chloride solution
B solid iron
C solid sodium chloride
D solid sulfur

[J12/P1/Q15]

3. Two particles have the compositions shown.

	electrons	neutrons	protons
X	4	6	5
Y	6	4	5

Which statement about X and Y is correct?

A They are both positively charged.
B They are particles of the same element.
C They have the same mass number.
D They have the same number of nucleons.

[N12/P1/Q4]

4. Which of the following is **not** a mixture?

A ethanol
B petrol
C steel
D tap water

[N12/P1/Q4]

5. Carbon and silicon are both in Group IV of the Periodic Table, but at room temperature CO_2 is a gas whereas SiO_2 is a solid.
Which statement explains this?

A Covalent bonding is weaker in CO_2.
B Covalent bonds in CO_2 are double bonds and in SiO_2 the covalent bonds are single bonds.
C CO_2 is a covalent compound and SiO_2 is ionic.
D CO_2 is a simple covalent molecule and SiO_2 is a macromolecule.

[N12/P1/Q7]

6. Which substance has metallic bonding?

	conducts electricity		state of substance formed on reaction with oxygen
	when solid	when liquid	
A	✓	✓	solid
B	✓	✓	gas
C	×	✓	no reaction
D	×	×	solid

[N12/P1/Q10]

1. C Sulphur being a non metal will not conduct under any conditions. HC*l* can only conduct as a solution of it's ions. Lead being a metal will conduct in both molten and solid states. NaC*l* will conduct both in molten form and as an aqueous solution of it's ions.

2. B Iron, being a metal has a sea of delocalized electrons which can conduct electricity without chemically changing Iron.

3. B X and Y have the same proton number, therefore they are particles of the same element.
Option **A** is not correct as Y is not positively charged since it has more electrons then protons.
Options **C** & **D** are not correct as mass number of X = 5+6 = 11, and mass number of Y= 4 + 5 = 9. The number of neutrons of both particles is also different.

4. A Fact.

5. D Intermolecular forces are much weaker in a simple covalent molecule like CO_2 as compared to giant macromolecular structures like SiO_2. Thus CO_2 is a gas whereas SiO_2 is a solid at room temperature and pressure.

6. A A substance with metallic bonding will conduct in both solid and molten (liquid) forms and will form a solid on reaction with oxygen.

7. Naturally-occurring bromine has a relative atomic mass of 80 and consists entirely of two isotopes of relative atomic masses 79 and 81.

What can be deduced about naturally-occurring bromine from this information only?

A Bromine contains the two isotopes in equal proportions.

B Bromine has different oxidation states.

C Bromine isotopes have different numbers of protons.

D Bromine is radioactive.

[J13/P1/Q5]

8. Silicon carbide, SiC, has a structure similar to diamond. Boron nitride, BN, has a structure similar to graphite. Bronze is an alloy of copper and tin.

Which statements about SiC, BN and bronze are correct?

1 All are bonded covalently.

2 All except silicon carbide conduct electricity when solid.

3 All have high melting points.

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

[J13/P1/Q6]

9. Sodium is in Group I of the Periodic Table.

When sodium combines with chlorine, what happens to each sodium atom?

A It gains one electron from one chlorine atom.

B It shares one electron with one chlorine atom.

C It transfers one electron to one chlorine atom.

D It transfers two electrons to one chlorine atom.

[J13/P1/Q8]

10. Hydrogen and sulfur react to form the compound hydrogen sulfide.
Which row shows the type of bonding between hydrogen and sulfur and the electrical conductivity of liquid hydrogen sulfide?

	type of bonding	electrical conductivity in the liquid state
A	covalent	good
B	covalent	non-conductor
C	ionic	good
D	ionic	non-conductor

[J13/P1/Q9]

11. Which elements exist as diatomic molecules at room temperature?

A hydrogen, oxygen, helium

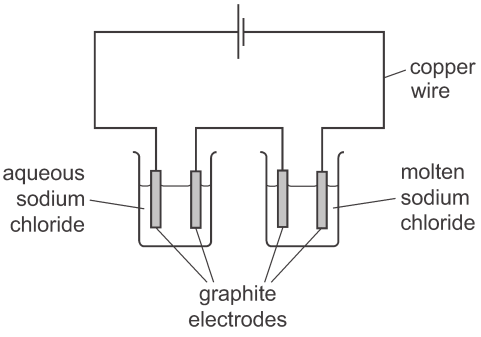
B nitrogen, chlorine, neon

C nitrogen, oxygen, fluorine

D oxygen, chlorine, helium

[N13/P1/Q2]

12. The diagram shows the electrolysis of aqueous sodium chloride and of molten sodium chloride.



Which substance in the diagram has both positive ions and mobile electrons?

A aqueous sodium chloride

B copper wire

C graphite electrodes

D molten sodium chloride

[N13/P1/Q5]

13. Substance X has a simple molecular structure and substance Y has a giant molecular structure.

Which row is correct?

	X could be	Y could be
A	an element only	an element only
B	an element only	an element or a compound
C	an element or a compound	an element only
D	an element or a compound	an element or a compound

[N13/P1/Q6]

Thinking Process

MCQ Answers

7. A The relative atomic mass of naturally occurring bromine is the exact average of the relative atomic masses of both isotopes.

8. C Atoms in Bronze are not bonded covalently .

9. C An ionic bond is formed between the atoms of sodium and chlorine. The sodium atom donates an electron and the chlorine atom accepts that electron for achieving stable state configuration .

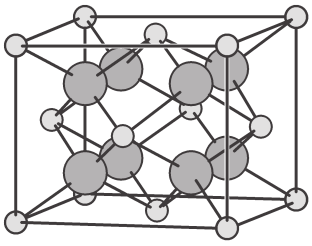
10. B Hydrogen sulfide has the formula H_2S and has covalent bonding between its atoms. It is a bad conductor of electricity due to the absence of free electrons .

11. C Noble gases do not exist as diatonic molecules at room temperature and pressure.

12. B Copper wire has metallic bonding which consists of positively charged metal ions surrounded by a sea of delocalized electrons.

13. D X could be iodine (an element) or water (a compound).
Similarly Y could be diamond (an element) or silica (a compound).

14. The diagram shows the structure of an ionic compound.



What is a possible formula for this compound?

A CaF_2 **B** NaC*l*
C SO_2 **D** MgO

[N13/P1/Q9]

15. Ionic compounds have high melting points because of the strong attraction between oppositely charged ions.

Which compound has the lowest melting point?

A $(Al^{3+})_2(O^{2-})_3$

B $Mg^{2+}O^{2-}$

C $Na^{+}Cl^{-}$

D $(Fe^{3+})_2(O^{2-})_3$

[N13/P1/Q29]

16. An ion X^+ has 23 nucleons and 10 electrons.

What does the nucleus of *X* contain?

	protons	neutrons
A	9	14
B	10	13
C	11	12
D	13	10

[J14/P1/Q6]

17. Which element exists as a macromolecule?

A carbon **B** hydrogen
C oxygen **D** sodium

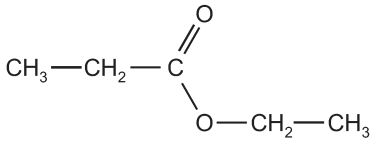
[J14/P1/Q7]

18. Which substance can conduct electricity by the movement of ions?

A copper
B graphite
C mercury
D sodium chloride

[J14/P1/Q8]

19. The diagram shows the molecule ethyl propanoate.



Consider **all** the electrons in a molecule of ethyl propanoate.

How many electrons **not** involved in bonding are there in the molecule?

A 8 **B** 10
C 18 **D** 22

[J14/P1/Q9]

20. In which solid can layers of atoms slide over each other?

A diamond **B** graphite
C haematite **D** silica

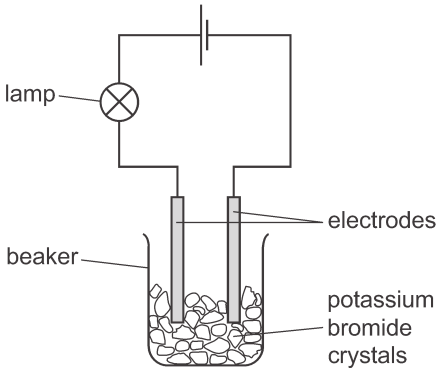
[J14/P1/Q27]

21. Which gas is **neither** an element **nor** a compound?

A ammonia
B chlorine
C air
D carbon monoxide

[N14/P1/Q5]

22. The experiment shown is used to test potassium bromide crystals.



The lamp does not light.

Distilled water is then added to the beaker and the lamp lights.

Which statement explains these results?

A Electrons are free to move in the solution when potassium bromide dissolves.

B Metal ions are free to move when potassium bromide melts.

Thinking Process

MCQ Answers

14. A For NaC*l* and MgO, the ionic compound must have an equal number of anions and cations. SO_2 is a covalent compound.

15. C The greater the charge, the stronger the ionic bond, and thus, the higher the melting point. Al_2O_3, MgO, and Fe_2O_3 have greater number of charges than NaC*l*, causing it to have the lowest melting point.

16. C X^+ has 10 electrons. Therefore *X* has 11 electrons, 11 protons and 23 – 11 = 12 neutrons.

17. A Carbon exists as a macromolecule in the form of diamond.

18. D Sodium chloride, in molten form, conducts electricity by the movement of ions. Copper, gra-phite and mercury conduct electricity by the movement of electrons.

19. D Carbon, hydrogen and oxygen have 6, 1 and 8 electrons respectively.
Number of electrons not involved in bonding are:

2 in CH_3—

2 in — CH_2 —

(2 + 6) in —C(=O)—

6 in — O —

2 in — CH_2 —

2 in — CH_3

Therefore, total number of electrons not involved in bonding = 2 + 2 + 8 + 6 + 2 + 2 = 22

20. B Fact.

C Metal ions are free to move when potassium reacts with water.

D Oppositely charged ions are free to move in the solution when potassium bromide dissolves.

[N14/P1/Q8]

23. How many electrons are used in covalent bonding in the N_2 molecule?

A 2 **B** 4

C 6 **D** 10

[N14/P1/Q9]

24. Propene, $CH_3CH = CH_2$, has a very low boiling point because of the weakness of the

A C – C bond.

B C = C bond.

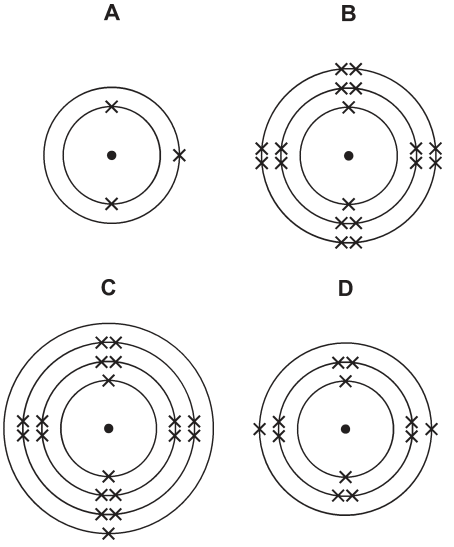
C C – H bond.

D intermolecular forces.

[N14/P1/Q10]

25. The diagram shows the arrangement of electrons in the atoms of four different elements.

Which is the **least** reactive of the four elements?



[N14/P1/Q26]

26. Which molecules all contain one or more double covalent bonds?

A chlorine, nitrogen and methane

B chlorine, oxygen and ethene

C oxygen, hydrogen chloride and ethene

D oxygen, carbon dioxide and ethene

[J15/P1/Q3]

27. The metals Cr, Co, Fe and Mn are all transition elements.

Which particles have the same number of electrons?

A Co^{2+} and Cr

B Co^{2+} and Fe^{3+}

C Cr and Mn^{2+}

D Fe^{3+} and Mn^{2+}

[J15/P1/Q4]

28. Which substance has metallic bonding?

	conducts electricity		state of product formed on reaction with oxygen
	when solid	when liquid	
A	✓	✓	solid
B	✓	✓	gas
C	×	✓	no reaction
D	×	×	solid

[J15/P1/Q5]

29. Which compound contains only eight covalent bonds?

A

B

C

D

[J15/P1/Q6]

30. What happens when sodium chloride melts?

A Covalent bonds in a giant lattice are broken.

B Electrons are released from atoms.

C Electrostatic forces of attraction between ions are overcome.

D Molecules are separated into ions.

[J15/P1/Q9]

MCQ Answers

21. C Air is a mixture of different compounds but is not a compound itself.

22. D Solid Potassium bromide is an ionic compound which contains fixed oppositely charged ions, which are not free to move. Thus it cannot conduct electricity.

23. C Each Nitrogen atom shares it's 3 valence shell electrons to form a covalent bond. Hence a total of 6 electrons are used in the covalent bond.

24. D Propene has a simple molecular structure with weak intermolecular forces of attraction. It therefore has a low melting and boiling point.

25. B Option **B** has a stable electronic configuration and is thus the least reactive.

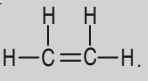
26. D Chlorine molecule contains single bond (Cl—Cl).

Hydrogen chloride contains single bond (H—Cl).

Oxygen contains O=O.

Carbon dioxide contains O=C=O.

Ethene contains



27. D

Particles		Electron
CO^{2+}	:	57
Cr	:	52
Fe^{3+}	:	53
Mn^{2+}	:	53

Hence, Fe^{3+} and Mn^{2+} have same number of electrons.

31. The following data may refer to the atom or to the ion of the same element.

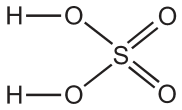
- electronic configuration 2,8,8
- nucleon number 40
- proton number 20

Which element is described by these data?

A argon **B** calcium
C chlorine **D** neon

[N15/P1/Q6]

32. A molecule of sulfuric acid has the structural formula shown.



How many electrons are involved in forming all the covalent bonds in one molecule?

A 6 **B** 8
C 12 **D** 16

[N15/P1/Q7]

33. Which statement about graphite is **not** correct?

A It burns to form carbon dioxide.
B It is a carbon compound.
C It is a giant molecular substance.
D It is used as a lubricant.

[N15/P1/Q24]

34. Which statement about the isotopes of bromine is correct?

They are atoms with the same number of

A electrons and a different number of protons.
B neutrons and the same number of electrons.
C protons and the same chemical properties.
D protons and the same physical properties.

[J16/P1/Q4]

35. Compound Z is made from element X and element Y. Compound Z is a good conductor of electricity when molten but not when solid.

Which statement is correct?

A Compound Z has strong forces of attraction between electrons and positive ions.
B Compound Z has strong forces of attraction between negative ions and positive ions.
C Elements X and Y are both metals.
D Elements X and Y are both non-metals.

[J16/P1/Q5]

36. Which statement shows that graphite and diamond are different forms of the element carbon?

A Both graphite and diamond have giant molecular structures.
B Complete combustion of equal masses of graphite and diamond produces equal masses of carbon dioxide and no other products.
C Graphite and diamond have different melting points.
D Graphite conducts electricity, whereas diamond does not.

[J16/P1/Q7]

37. Ethene, C_2H_4, is a covalent compound with a simple molecular structure.

Which statement about ethene is correct?

A Ethene is a liquid at room temperature and pressure.
B Liquid ethene conducts electricity.
C One ethene molecule contains sixteen protons.
D The total number of shared pairs of electrons in ethene is five.

[J16/P1/Q8]

38. An atom of an element has eight electrons only.

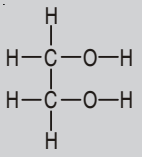
Which statement about this element is correct?

A It forms an ion with two negative charges.
B It has a full outer shell of electrons.
C It is a metal.
D It is in Group VIII of the Periodic Table.

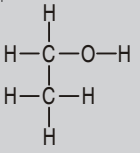
[J16/P1/Q25]

28. A A metallic substance contains metallic bonding which allows it to conduct electricity in solid and liquid states. When a metal reacts with oxygen, a solid metal oxide is formed.

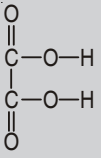
29. B Option **A** has 9 covalent bonds.



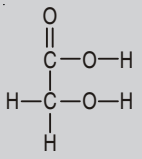
Option **B** has 8 covalent bonds.



Option **C** has 9 covalent bonds.



Option **D** has 9 covalent bonds.



30. C Sodium chloride is an ionic compound.

31. B Proton number of 20 corresponds to the element calcium.

32. D Four electrons are involved in each S=O covalent bond. Two electrons are involved in each S— O covalent bond. Two electrons are involved in each O—H covalent bond. Therefore, total number of electrons involved in bonding
$=(2\times4)+(2\times2)+(2\times2)$
$=16$ electrons.

Topic 3 *Atomic Structure / Chemical Bonding*

THEORY Section

Question 1

Choose from the following particles to answer the questions below.

$^{8}_{4}\mathbf{Be}$

$^{14}_{6}\mathbf{C}$

$^{40}_{20}\mathbf{Ca}$

$^{37}_{17}\mathbf{Cl}^{-}$

$^{39}_{19}\mathbf{K}^{+}$

$^{24}_{12}\mathbf{Mg}^{2+}$

$^{20}_{10}\mathbf{Ne}$

$^{17}_{8}\mathbf{O}$

$^{16}_{8}\mathbf{O}^{2-}$

$^{32}_{16}\mathbf{S}^{2-}$

$^{28}_{14}\mathbf{Si}^{4-}$

Each particle can be used once, more than once or not at all.
Which particle

(a) has only eight electrons, [1]

(b) is attracted to the cathode during electrolysis, [1]

(c) has only four electrons in its outer shell, [1]

(d) has only eight neutrons, [1]

(e) has only ten protons, [1]

(f) has four occupied electron shells? [1]

[J12 / P2 / Q1]

Solution

(a) $^{17}_{8}\mathbf{O}$

(b) $^{39}_{19}\mathbf{K}^{+}$

(c) $^{14}_{6}\mathbf{C}$

(d) $^{16}_{8}\mathbf{O}^{2-}$

(e) $^{20}_{10}\mathbf{Ne}$

(f) $^{40}_{20}\mathbf{Ca}$

COMMENT on **ANSWER**

"(b) $^{24}_{12}Mg^{+2}$ is also attracted to the cathode during electrolysis.

(d) $^{14}_{6}C$ also has 14 – 6 = 8 neutrons."

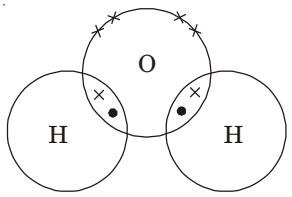
Question 2

Draw a 'dot-and-cross' diagram for a molecule of water.
Show only the outer shell electrons. [2]

[N12 / P2 / Q1(c)]

Solution

(a)

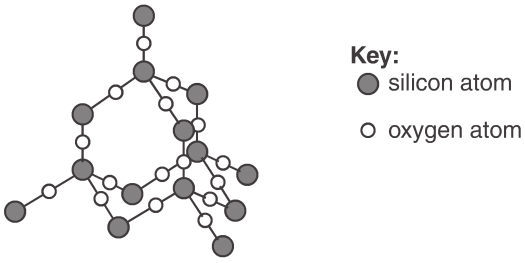


Key:
- • electron of hydrogen
- × electron of oxygen

Question 3

Glass contains silicon(IV) oxide and a number of metal oxides.

(a) The structure of silicon(IV) oxide is shown below.

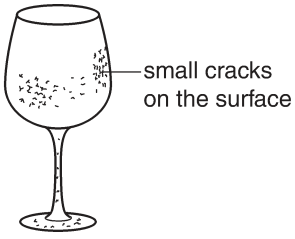


(i) Describe **two** similarities in the structure of silicon(IV) oxide and diamond. [2]

(ii) Explain why silicon(IV) oxide has a high melting point. [2]

(iii) Explain why silicon(IV) oxide does not conduct electricity. [1]

(b) Old wine glasses often appear cloudy because they have many small cracks on their surface.



The cracks are caused by differences in the rate of diffusion of sodium ions and hydrogen ions in the glass.

(i) Explain the meaning of the term *diffusion*. [1]

(ii) Suggest why sodium and hydrogen ions do not diffuse at the same rate. [1]

(c) Sodium oxide is an ionic compound.
Draw a 'dot-and-cross' diagram to show

- the arrangement of the outer shell electrons,
- the charges on the ions and
- the formula of sodium oxide. [3]

[N12 / P2 / Q7]

Solution

(a) (i) 1. Both have a tetrahedral arrangement of atoms.
2. Both have giant macromolecular structures.

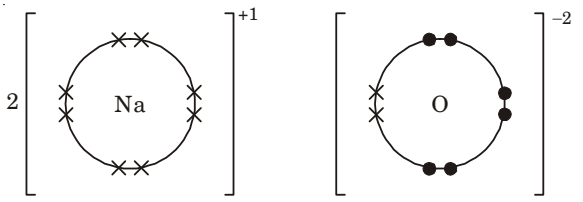
(ii) Silicon (IV) oxide contains strong covalent bounds which require a lot of energy to be broken.

(iii) Silicon (IV) oxide contains no free electrons as all electrons are occupied in making covalent bonds.

(b) (i) Diffusion refers to random movement of molecules or particles in any direction.

(ii) Both the sodium and hydrogen ions have different masses causing them to diffuse at different rates.

(c)



Question 4

Silicon is an element in Group IV of the Periodic Table.

(a) Give the electronic configuration for a silicon atom. [1]

(b) Silicon has three naturally occurring isotopes.
Complete the following table for two of these isotopes.

isotope	^{28}Si	^{30}Si
number of protons		
number of electrons		
number of neutrons		

[3]

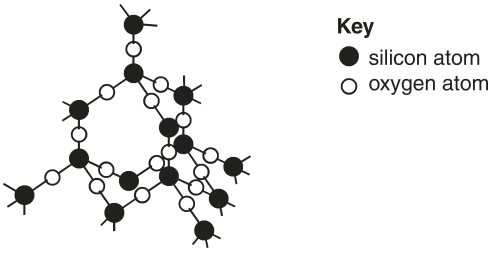
(c) Silicon reacts with chlorine on heating to form silicon(IV) chloride, $SiCl_4$.
Construct an equation for this reaction. [1]

(d) Silicon(IV) chloride is a simple molecular compound.

(i) Suggest **two** physical properties of silicon(IV) chloride other than solubility. [2]

(ii) Draw a 'dot-and-cross' diagram for silicon(IV) chloride.
You only need to show the outer shell electrons for each atom. [2]

(e) Silicon(IV) chloride reacts with water to form silicon(IV) oxide.
Part of the structure of silicon(IV) oxide is shown below.



Explain, in terms of structure and bonding, why silicon(IV) oxide has a very high melting point. [2]

[N13 / P2 / Q3]

Solution

(a) 2, 8, 4.

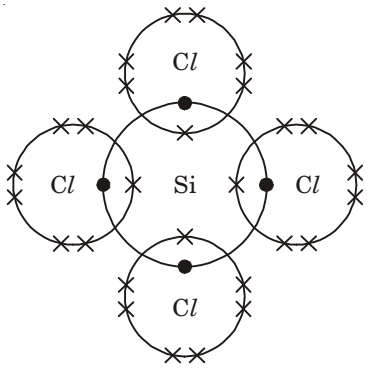
(b)

isotope	^{28}Si	^{30}Si
number of protons	**14**	**14**
number of electrons	**14**	**14**
number of neutrons	**14**	**16**

(c) $Si + 2Cl_2 \longrightarrow SiCl_4$

(d) (i) 1. It has a low melting and boiling point.
2. It is a bad conductor of heat and electricity.

(ii)



(e) Silicon(IV) oxide has a giant macromolecular structure with many strong covalent bonds. Breaking these bonds requires a lot of energy, which causes Silicon(IV) oxide to have a very high melting point.

Question 5

Astatine, At, is an element in Group VII of the Periodic Table.

The table shows some information about two isotopes of astatine.

symbol	number of protons	number of electrons	number of neutrons
$^{210}_{85}At$	.....	.....	.....
$^{211}_{85}At$	.....	.....	.....

(a) (i) Complete the table. [2]

(ii) What is meant by the term *isotopes*? [1]

(b) Astatine forms a diatomic molecule with the same type of bonding as in a chlorine molecule.
Draw the 'dot-and-cross' diagram for an astatine molecule.
Only draw the outer shell electrons. [1]

(c) Astatine reacts with magnesium to form magnesium astatide, $MgAt_2$, which contains Mg^{2+} and At^- ions.

(i) Describe how a magnesium ion and an astatide ion are formed from a magnesium atom and an astatine atom. [2]

(ii) Predict **two** physical properties of magnesium astatide. [2]

(d) (i) Bromine reacts with aqueous magnesium astatide. Construct the ionic equation for this reaction. [1]

(ii) Explain why astatine does not react with aqueous magnesium iodide. [1]

[J14/P2/Q10]

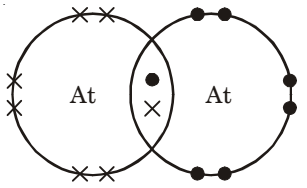
Solution

(a) (i)

symbol	number of protons	number of electrons	number of neutrons
$^{210}_{85}$At	**85**	**85**	**125**
$^{211}_{85}$At	**85**	**85**	**126**

(ii) Isotopes are atoms of the same element with same number of protons but different number of neutrons.

(b)



(c) (i) The bonding in Magnesium astatide is ionic. A magnesium atom loses two electrons to form a magnesium ion. Each astatine atom gains one electron to form an astatide ion.

(ii) 1. High melting point.

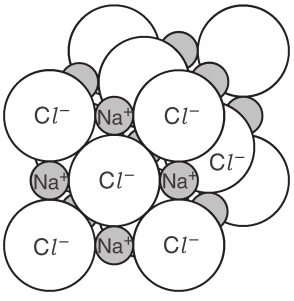
2. Does not conduct electricity as a solid.

(d) (i) $Br_2 + 2At^- \rightarrow 2Br^- + At_2$

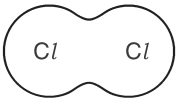
(ii) Astatine is less reactive than iodine.

Question 6

The structures of sodium chloride and chlorine are shown below.



sodium chloride



chlorine

(a) The melting point of sodium chloride is 801 °C.
The melting point of chlorine is –101 °C.

Explain, in terms of structure and bonding, the difference between the melting points of these two substances. [4]

(b) Explain why molten sodium chloride conducts electricity but solid sodium chloride does not. [1]

(c) Draw a 'dot-and-cross' diagram for sodium chloride, showing all the electron shells. [2]

(d) The electrode reactions occurring when molten sodium chloride is electrolysed are shown below.

negative electrode $Na^+ + e^- \rightarrow Na$

positive electrode $2Cl^- \rightarrow Cl_2 + 2e^-$

Refer to these equations to explain why this electrolysis involves both oxidation and reduction. [2]

(e) Chlorine reacts with excess ammonia, NH_3, to form hydrogen chloride and nitrogen. Construct an equation for this reaction. [1]

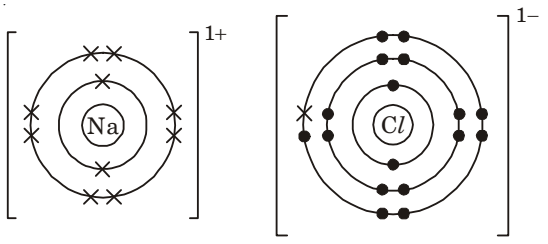
[N14 / P2 / Q6]

Solution

(a) Sodium chloride is a giant ionic structure with strong electrostatic forces of attraction between the oppositely charged ions. Chlorine has a simple covalent structure, with weak Van der Waal's forces of attraction between molecules. Hence the melting point of sodium chloride is much higher than that for chlorine.

(b) Ions cannot move in solid sodium chloride. In molten form, the ions are free to move and conduct electricity.

(c)



(d) Sodium ions gain electrons which is an example of reduction.

Chlorine ions lose electrons which is an example of oxidation.

(e) $2NH_3 + 3Cl_2 \longrightarrow 6HCl + N_2$

COMMENT on **ANSWER**

"**(c)** Na would lose one electron to obtain stable electronic configuration and will from the Na^+ ion.

Cl would gain one electron to complete it's octet and will form the Cl^- ion.

(d) The oxidation number of sodium decreases from +1 to 0 which is an example of reduction.

The oxidation number of chlorine increases from –1 to 0 which is an example of oxidation."

Question 7

Two isotopes of phosphorus are $^{31}_{15}P$ and $^{32}_{15}P$.

(a) State one difference and one similarity between these two isotopes. [2]

(b) Phosphorus forms simple molecules which have a relative molecular mass of 124.
Suggest the formula of a phosphorus molecule. [1]

(c) Phosphorus has a low melting point and does not conduct electricity.

(i) Explain why phosphorus has a low melting point. [1]

(ii) Explain why phosphorus does not conduct electricity. [1]

(d) Complete the table for $^{31}_{15}P^{3-}$.

number of neutrons	.....
number of protons	.....
electronic configuration	.....

[3]

(e) Phosphorus forms a compound called phosphine, PH_3.

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of phosphine.

Only draw the outer shell electrons. [2]

(f) Phosphine ignites in air to make water and phosphorus(V) oxide.

Construct the equation for this reaction. [2]

[J15 / P2 / Q3]

Solution

(a) Difference: Both isotopes contain different number of neutrons and thus have different atomic mass.

Similarity: Both have the same proton number and same number of electrons.

(b) P_4

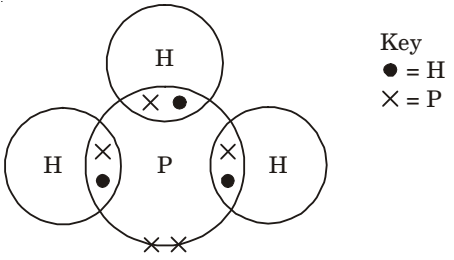
(c) (i) Phosphorus is a simple covalent molecule having weak intermolecular forces of attraction between molecules. Therefore less heat energy is required to break the intermolecular forces.

(ii) All electrons in phosphorous are used in bonding. Hence, it has no free electrons to conduct electricity.

(d)

number of neutrons	16
number of protons	15
electronic configuration	2, 8, 8

(e)



(f) $2PH_3 + 4O_2 \rightarrow P_2O_5 + 3H_2O$

COMMENT on **ANSWER**

"**(a)** Isotopes refer to atoms of the same element with different number of neutrons. They have same chemical properties but have different physical properties.

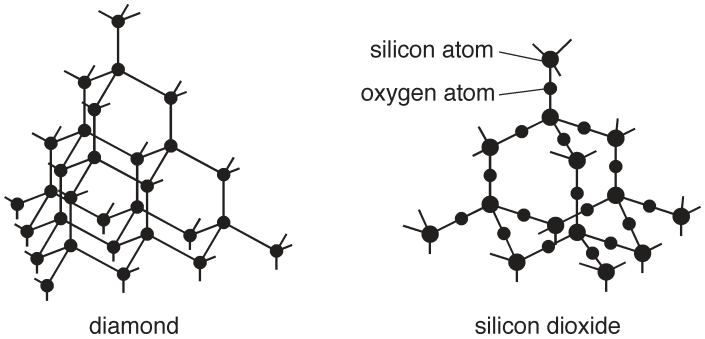
(b) $\text{Moles} = \frac{\text{Mass}}{M_r} = \frac{124}{31} = 4$

(d) The electronic configuration of phosphorus atom is 2, 8, 5.

Electronic configuration of phosphorus ion is = 2, 8, 8. "

Question 8

The structures of diamond and silicon dioxide are shown.



diamond silicon dioxide

(a) Describe one similarity in the structures of diamond and silicon dioxide. [1]

Topic 12 *Organic Chemistry*

M C Q S e c t i o n

1. Which compound has more than two carbon atoms per molecule?

A ethanoic acid
B ethanol
C ethene
D ethyl ethanoate

[J12/P1/Q35]

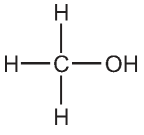
2. The equations show some reactions of organic compounds.

Which is an addition reaction?

A $CH_4 + Br_2 \rightarrow CH_3Br + HBr$
B $C_2H_5OH + O_2 \rightarrow CH_3CO_2H + H_2O$
C $C_2H_5OH + CH_3CO_2H \rightarrow CH_3CO_2C_2H_5 + H_2O$
D $C_4H_4 + 2Br_2 \rightarrow C_4H_4Br_4$

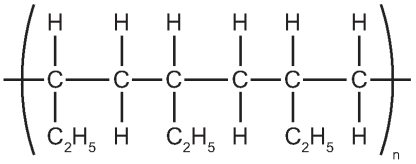
[J12/P1/Q36]

3. Which statement about methanol is correct?

A It can be oxidised to form methanoic acid.
B It is a constituent of alcoholic drinks.
C It is formed by fermentation.
D Its fully displayed structural formula is 

[J12/P1/Q37]

4. The section of a polymer chain is shown.



Which molecule would produce this polymer and by which type of polymerisation?

	molecule	type of polymerisation
A	$CH_3–CH=CH–CH_3$	condensation
B	$CH_3–CH_2–CH=CH_2$	addition
C	$CH_3–CH_2–CH_2–CH=CH_2$	condensation
D	$CH_3–CH=CH–CH_3$	addition

[J12/P1/Q40]

5. Which compound contains only eight covalent bonds?

A 

B 

C 

D 

[N12/P1/Q17]

6. A factory manufactures poly (ethene).

Which raw material will the factory need?

A bitumen
B methane
C methanol
D naphtha

[N12/P1/Q35]

7. Starch is a carbohydrate and is broken down to simple sugars by saliva in the mouth.

What is the name for this reaction?

A condensation
B fermentation
C hydrolysis
D polymerisation

[N12/P1/Q36]

1. D Ethanoic Acid: CH_3COOH.

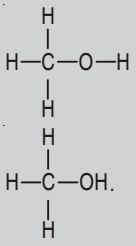
Ethanol: CH_3CH_2OH.

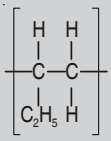
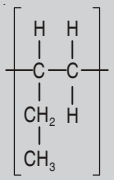
Ethene: C_2H_4

Ethyl Ethanoate: $CH_3COOCH_2CH_3$

Therefore only Ethyl Ethanoate has more then 2 carbon atoms per molecule.

2. D Reaction **A** is a substitution reaction.
Reaction **B** is an oxidation reaction.
Reaction **C** is a condensation reaction.
Reaction **D** is an addition reaction.

3. A Methanol can be oxidized by acidified potassium dichromate to form methanoic acid. Also, the fully displayed structural formula of methanol is  and not .

4. B Such a polymer is formed by addition polymerization. The repeat unit would be,  or 

8. If 1 mole of each alkane is completely burned in oxygen, which will provide 7 moles of products?

A CH_4 **B** C_2H_6

C C_3H_8 **D** C_4H_{10}

[N12/P1/Q37]

9. An alcohol contains 60% carbon by mass.

What is its formula?

A CH_3OH **B** C_2H_5OH

C C_3H_7OH **D** C_4H_9OH

[N12/P1/Q38]

10. The alcohol C_4H_9OH on oxidation with acidified potassium dichromate (VI) will give a carboxylic acid X.

Which acid is X?

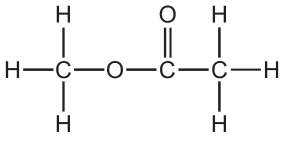
A C_4H_9COOH **B** C_3H_7COOH

C C_2H_5COOH **D** CH_3COOH

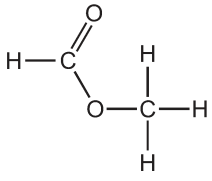
[N12/P1/Q39]

11. Which compound has a pH of less than 7 ?

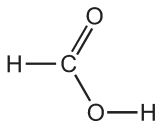
A



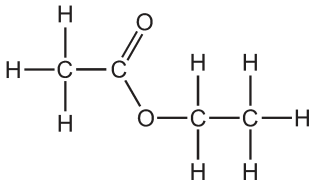
B



C



D



[N12/P1/Q40]

12. Which organic compound requires the least oxygen for the complete combustion of one mole of the compound?

A C_3H_7OH **B** C_3H_7COOH

C C_3H_8 **D** C_4H_8

[J13/P1/Q35]

13. Which polymer contains only three elements?

A protein

B poly(ethene)

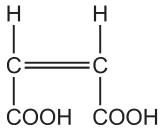
C poly(propene)

D starch

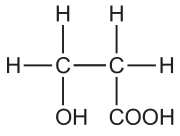
[J13/P1/Q36]

14. What are the reactions of compounds W, X, Y and Z?

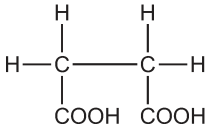
W



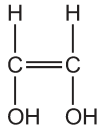
X



Y



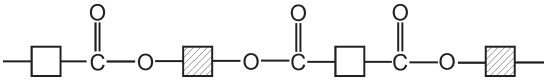
Z



	decolourises aqueous bromine	has a pH of less than 7	reacts with a carboxylic acid to form an ester
A	X and Y	W, X and Y	W, X , Y and Z
B	X and Y	X and Z	X and Z
C	W and Z	W, X and Y	X and Z
D	W and Z	X and Z	W, X and Y

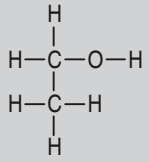
[J13/P1/Q37]

15. The diagram shows the partial structure of *Terylene*.



MCQ Answers

5. B The displayed structural formula of option **B** is:

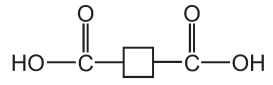
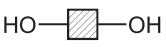


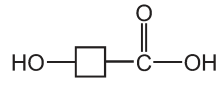
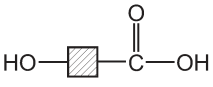
which shows only 8 covalent bonds.

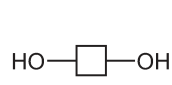
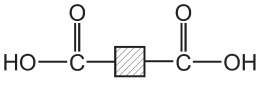
6. D Ethene can be obtained from the cracking of naphtha. It can then be used to make poly(ethene).

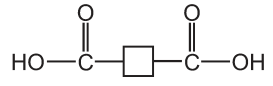
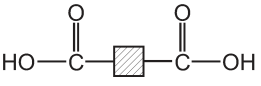
7. C The chemical breakdown of a compound due to reaction with water is known as hydrolysis. Saliva contains an enzyme, amylase, which catalyses the hydrolysis of starch to simple sugars.

From which pair of compounds is it made?

A  + 

B  + 

C  + 

D  + 

[J13/P1/Q38]

16. Which straight chain hydrocarbon can form a polymer by addition polymerisation?

A C_6H_{14} **B** C_7H_{14}

C C_8H_{18} **D** C_9H_{20}

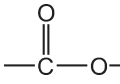
[J13/P1/Q39]

17. Both nylon and the proteins found in egg yolk are polymers.

Which statement about nylon and these proteins is correct?

A They are both naturally occurring macromolecules.

B They are both polyamides.

C They both possess the  linkage.

D They can both be hydrolysed to form amino acids.

[N13/P1/Q35]

18. An organic compound has an empirical formula C_2H_4O.

What could the compound be?

A butanoic acid

B butanol

C ethanoic acid

D ethanol

[N13/P1/Q36]

MCQ Answers

8. C Option **A**: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Option **B**: $C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O$

Option **C**: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Option **D**: $C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O$

It can be seen that 7 moles of products are formed in option **C** only.

9. C Percentage of carbon in C_3H_7OH is

$$= \frac{12\times3}{12\times3+7\times1+16\times1+1\times1}\times100$$

$$= \frac{36}{60}\times100 = 60\,\%$$

10. B C_4H_9OH can be written as $C_3H_7CH_2OH$. A primary alcohol ($R\text{-}CH_2OH$) is oxidised to a carboxylic acid ($R\text{-}CO_2H$). Thus $C_3H_7CH_2OH$ will be oxidised to $C_3H_7CO_2H$.

11. C Option **C** is a Carboxylic acid. Carboxylic acids have a pH of less then 7.

12. A $C_3H_7OH + \frac{9}{2}O_2 \rightarrow 3CO_2 + 4H_2O$

$C_3H_7COOH + 5O_2 \rightarrow 4CO_2 + 4H_2C$

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

$C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

13. D Starch contains hydrogen, carbon and oxygen only.

14. C W and Z both have a carbon to carbon double covalent bond which decolourises aqueous bromine. W, X, Y have a —COOH group which causes them to have a pH of lesser than 7. X and Z have a —OH group which can react with a carboxylic acid to form an ester.

15. A Fact.

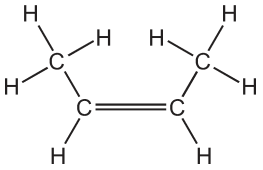
16. B Addition polymerization occurs in Alkenes which have a general formula C_nH_{2n}. Only C_7H_{14} is an Alkene and can be made into a polymer by addition polymerization.

17. B Nylon and proteins found in egg yolk contain the amide linkage, and hence are polyamides.

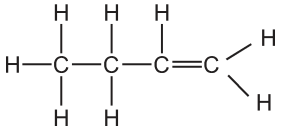
18. A The formula of butanoic acid is $C_3H_7CO_2H$. It's molecular formula is $C_4H_8O_2$. Hence, the empirical formula of butanoic acid = C_2H_4O

19. Which diagram shows the structure of the monomer of poly(propene)?

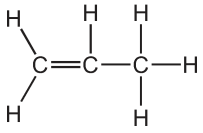
A



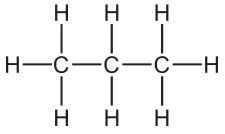
B



C



D

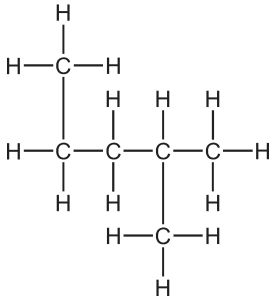


[N13/P1/Q37]

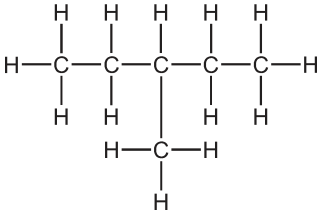
20. Alkanes are saturated compounds containing carbon and hydrogen only.

Structures 1, 2, 3 and 4 are saturated hydrocarbons.

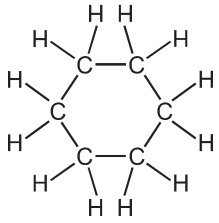
1



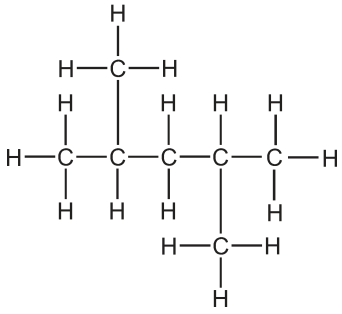
2



3



4



Which pair of structures are isomers?

A 1 and 2 **B** 1 and 4

C 2 and 3 **D** 2 and 4

[N13/P1/Q38]

21. Which pair of compounds are both esters and are isomers of each other?

A HCO_2CH_3 and CH_3CO_2H

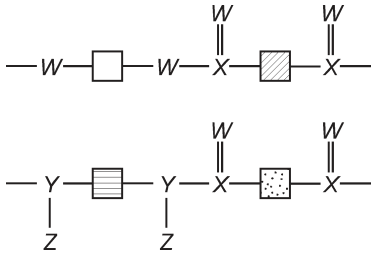
B $CH_3CO_2CH_3$ and $C_2H_5CO_2H$

C $CH_3CO_2C_2H_5$ and $C_2H_5CO_2CH_3$

D $C_3H_7CO_2CH_3$ and $CH_3CO_2C_2H_5$

[N13/P1/Q39]

22. The diagram shows the partial structures of two different polymers.



MCQ Answers

19. C A monomer of poly(propene) would be a molecule of propene itself.

20. A Molecular formula of :

Structure 1 = C_6H_{14}

Structure 2 = C_6H_{14}

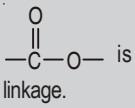
Structure 3 = C_6H_{14}

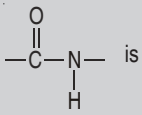
Structure 4 = C_7H_{14}

Hence 1 and 2 are isomers, as they have the same molecular formula.

21. C In options **A** and **B**, the latter compound is a carboxylic acid. In option **D**, the pair of compounds do not have the same molecular formula and hence are not isomers of each other.

22. C

 is the ester linkage.

 is the amide linkage.

Topic 12 *Organic Chemistry*

THEORY Section

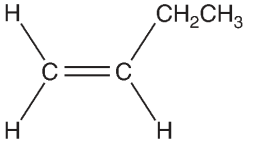
Question 1

The typical composition of solid domestic waste in a city is shown below.

type of solid waste	percentage by mass
glass	9
metals	8
organic waste including food	22
paper	38
plastics	9
textiles	2
other	12

(a) The most abundant metals in the solid waste are aluminium, copper and iron. Describe **two** advantages of recycling these metals. [2]

(b) One of the polymer molecules in the plastic waste is made from the monomer shown below.



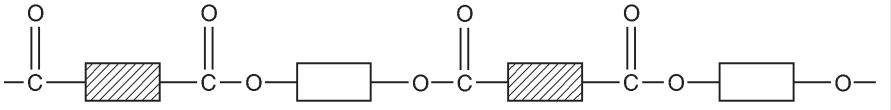
Draw the partial structure of the polymer formed from this monomer showing two repeats. [2]

(c) Many of the polymers found in the plastic waste are non-biodegradable.

Describe **two** pollution problems caused by the disposal of non-biodegradable polymers. [2]

(d) *Terylene* and nylon are two of the textiles present in the solid waste.

The partial structure of *Terylene* is shown below.



(i) *Terylene* is a polyester.

What type of polymerisation is used to make *Terylene*? [1]

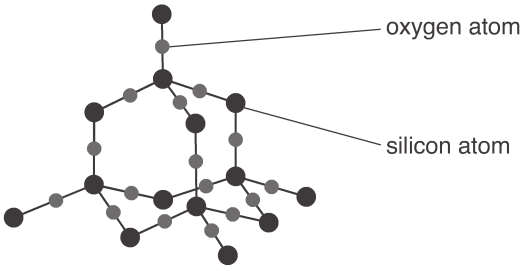
(ii) Complete the diagram below to show the partial structure for nylon.

[1]

(iii) Give the name of one **type** of food that has molecules containing the same linkages as Terylene. [1]

(e) Glass is made from sand.

Pure sand has a giant molecular structure.



(i) What is the formula for pure sand? [1]

(ii) Explain why sand has a very high melting point. [2]

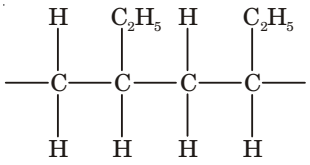
(iii) Explain why sand does not conduct electricity. [1]

[J12 / P2 / Q3]

Solution

(a) The recycling of these metals saves energy as more energy is needed to extract the metals from their ores than the amount of energy required to recycle them. Also, by recycling these metals, there would be less landfill and litter which would lead to reduced disposal problems.

(b)

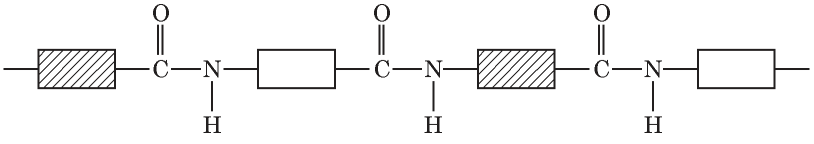


(c) 1. The incineration of non-biodegradable polymers, during their disposal, produces hazardous and toxic gases.

2. The non-biodegradable polymers being dumped into rivers, streams and seas, contaminate the water and harm marine life.

(d) (i) Condensation polymerisation

(ii)



(iii) Fats

(e) (i) SiO_2

(ii) Sand molecules consist of a giant macromolecular structure in which atoms are joined together by strong covalent bonds. It takes a lot of energy to break such bonds, causing sand to have very high melting point.

(iii) Sand does not contain any free or delocalised electrons as all the electrons are being used to form the covalent bonds. Hence, it does not conduct electricity.

COMMENT on **ANSWER**

"**(a)** Other advantages include:

1. Recycling reduces the need for mining and hence there is less scarring of the landscape.

2. Recycling of these metals helps to reduce the formation of toxic and harmful gases.

(c) Other pollution problems include:

1. More landfill sites are needed for the disposal of the non-biodegradable polymers.

2. CO and CO_2 released due to burning of non-biodegradable polymers cause air pollution and global warming respectively. "

Question 2

Alkenes are a homologous series of organic compounds.
The table shows some information about the first six alkenes.

name	molecular formula	melting point / °C	boiling point / °C
ethene	C_2H_4	–169	–104
propene	C_3H_6	–185	–48
butene	C_4H_8	–185	–6
pentene	C_5H_{10}	–165	30
hexene	C_6H_{12}	–139	63
heptene	C_7H_{14}		

(a) Draw the structure, showing all the atoms and bonds, of propene.
Use the structure to explain why propene is both a *hydrocarbon* and *unsaturated*. [3]

(b) There are several compounds with molecular formula C_4H_8, each has a different structure.
What name is given to compounds with the same molecular formula but different structures? [1]

(c) Deduce the molecular formula for decene, an alkene with 10 carbon atoms per molecule. [1]

(d) Explain why it is easier to predict the boiling point of heptene rather than its melting point. [1]

(e) What is the physical state for butene at room temperature and pressure? Explain your answer. [1]

(f) Many alkenes are manufactured by the cracking of long chain alkanes such as hexadecane, $C_{16}H_{34}$.
Construct an equation to show the cracking of hexadecane to form butane and butene only. [1]

(g) Butene reacts with bromine and with steam.

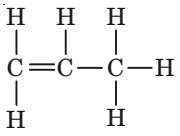
(i) Give the molecular formula of the product with bromine. [1]

(ii) Suggest the name of the product with steam. [1]

[J12/P2/Q8]

Solution

(a)



Propene is a hydrocarbon as it contains atoms of hydrogen and carbon only.

It is unsaturated as it contains a carbon-carbon double bond $\left(\rangle C{=}C\langle\right)$.

(b) Isomer.

(c) $C_{10}H_{20}$.

(d) In the given table, we see that the melting point is irregular down the series whereas the boiling point increases regularly down the series. Therefore it is easier to predict the boiling point of heptene.

(e) physical state: Gas

explanation: The boiling point is lower than the room temperature.

(f) $C_{16}H_{34} \rightarrow 3C_4H_8 + C_4H_{10}$

(g) **(i)** $C_4H_8Br_2$

(ii) Butan-1-ol

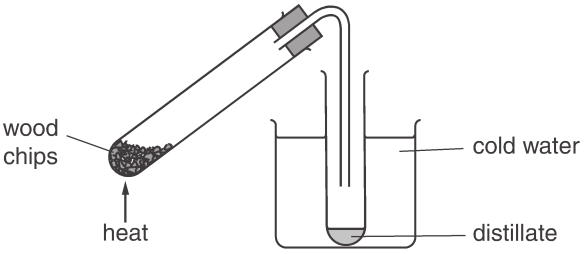
COMMENT on **ANSWER**

"**(g)** **(ii)** Butan-2-ol could also have been formed by reacting Butene with Bromine and steam."

Question 3

Wood is made up of many different carbon compounds.

(a) When wood is heated in the absence of air, the carbon compounds in the wood decompose.



The distillate contains a number of organic compounds, including

ethanoic acid
ethanal
ethanol
methanol

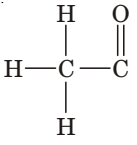
(i) When calcium hydroxide is added to the distillate, it neutralises the ethanoic acid.
Name the salt formed in this neutralisation. [1]

(ii) Ethanal can be removed from the distillate by a second distillation. On what physical property of ethanal does this distillation depend? [1]

(iii) The composition by mass of ethanal is C 54.5%, H 9.1%, O 36.4%. Calculate the empirical formula of ethanal. [2]

(b) Ethanol reacts with ethanoic acid to form the ester ethyl ethanoate.

(i) Complete the following formula for ethyl ethanoate.



[1]

(ii) State a commercial use for esters. [1]

[N12 / P2 / Q4(b,c)]

Solution

(a) (i) Calcium ethanoate

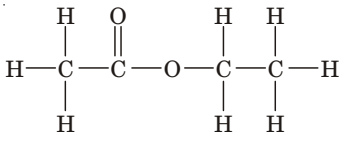
(ii) Boiling point

(iii)

element	C	H	O
%	54.5	9.1	36.4
Ar	12	1	16
no. of moles	$\frac{54.5}{12}$	$\frac{9.1}{1}$	$\frac{36.4}{16}$
=	4.542	9.1	2.275
simple ratio	$\frac{4.542}{2.275}$	$\frac{9.1}{2.275}$	$\frac{2.275}{2.275}$
=	2	4	1

empirical formula = C_2H_4O

(b) (i)



(ii) Making perfumes.

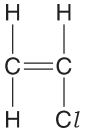
COMMENT on **ANSWER**

"**(b)** **(ii)** Esters may also be used in the formation of solvents, flavourings, polyesters, terylene, nail varnish remover, etc. "

Question 4

Chlorine and sodium hydroxide are manufactured by the electrolysis of concentrated aqueous sodium chloride.

(a) Chlorine is used to make chloroethene.
The structure of chloroethene is shown below.



(i) Draw the structure of the polymer poly(chloroethene). [2]

(ii) Chloroethene is an unsaturated compound.
Describe a positive test for an unsaturated compound. [2]

(b) Sodium hydroxide is a typical alkali.
It reacts with ethanoic acid to form water and the ionic salt, sodium ethanoate.

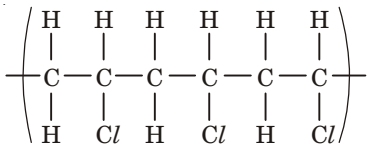
(i) Write the formula for the ethanoate ion showing all atoms and bonds. [1]

(ii) Construct the ionic equation for the reaction of ethanoic acid with sodium hydroxide. [1]

[N12 / P2 / Q9(b,c)]

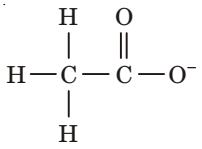
Solution

(a) (i)



(ii) test: Add aqueous bromine.
result: Aqueous bromine turns colourless.

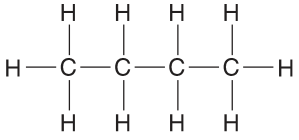
(b) (i)



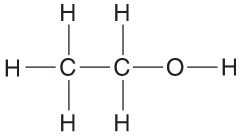
(ii) $CH_3COOH + OH^- \longrightarrow CH_3COO^- + H_2O$

Question 5

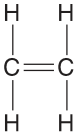
The structures of some of the compounds that can be manufactured from crude oil are shown.



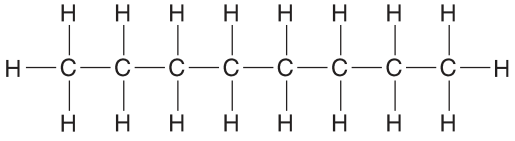
butane



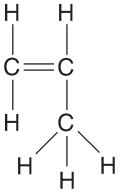
ethanol



ethene



octane



propene

(a) Octane is found in the petrol fraction separated from crude oil.
Name the process by which petrol is separated from crude oil and state the physical property which allows this process to be carried out. [2]

(b) Hexadecane, $C_{16}H_{34}$, can be cracked to produce a mixture of alkanes and alkenes.
Construct an equation to show the cracking of hexadecane to produce octane. [2]

(c) Propene can be polymerised to make poly(propene).
Draw a section of the structure of poly(propene). [2]

(d) Ethanol is manufactured by a hydration reaction.
State both the reagents and conditions for this reaction. [2]

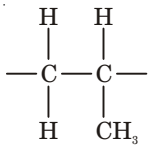
[J13 / P2 / Q4]

Solution

(a) Name of process: Fractional distillation.
Physical property: Boiling point.

(b) $C_{16}H_{34} \longrightarrow C_8H_{18} + C_8H_{16}$

(c)



COMMENT on **ANSWER**

❝ **(b) (ii)**

$CH_3COOH(aq) + NaOH(aq)$

$\rightarrow CH_3COO^-Na^+(aq) + H_2O(l)$

Sodium acts as a spectator ion and thus can be removed from the ionic equation. ❞

COMMENT on **ANSWER**

❝ **(b)** Other equation could have been:

$C_{16}H_{34} \rightarrow C_8H_{18} + 2C_4H_8$

$C_{16}H_{34} \rightarrow C_8H_{18} + 4C_2H_4$

$C_{16}H_{34} \rightarrow C_8H_{18} + C_4H_8 + 2C_2H_4$ ❞

(d) Reagents: Ethene and steam
Conditions: Heat and catalyst (Phosphoric acid)

Question 6

Alcohols are a homologous series of organic compounds.
The table shows information about some alcohols.

alcohol	molecular formula	melting point / °C	density / g / cm^3
methanol	CH_4O	– 98	0.79
ethanol	C_2H_6O	– 114	0.79
	C_3H_8O	– 126	0.80
butanol	$C_4H_{10}O$		
decanol		7	0.83

(a) Which group of atoms (functional group) must be present in the homologous series of alcohols? [1]

(b) Name the alcohol with the molecular formula C_3H_8O. [1]

(c) **(i)** Deduce the general formula for an alcohol. [1]

(ii) A molecule of decanol has ten carbon atoms.
What is the molecular formula for decanol? [1]

(d) It is more difficult to estimate the melting point of butanol than to estimate its density.
Use the data in the table to explain why. [1]

(e) When warmed in the presence of concentrated sulfuric acid, butanol reacts with ethanoic acid to form an ester.
Name and draw the structure, showing all the atoms and all the bonds, of this ester. [2]

(f) Ethanol reacts with oxygen in the air to form ethanoic acid.
Describe another method by which ethanol can be converted into ethanoic acid. [2]

(g) Butanol can burn in a **limited** supply of air.
Name **two** products of this reaction. [1]

[J13 / P2 / Q8]

Solution

(a) Hydroxyl (–OH)

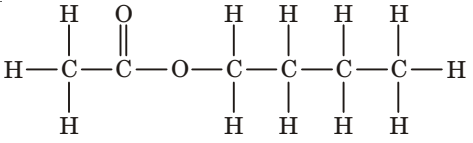
(b) Propanol

(c) **(i)** $C_nH_{2n+1}OH$

(ii) $C_{10}H_{22}O$

(d) Melting point does not have a regular trend down the series, however the density does.

(e) Name: Butyl ethanoate.
Structure:



COMMENT on **ANSWER**

"**(b)** Propan-1-ol and propan-2-ol would also have been acceptable answers."