Candidate 2 Evidence

MARKS

SECTION 2 —60 marks

Attempt ALL questions

1. A sample of argon contains three types of atom.

$^{36}_{18}Ar$ $^{38}_{18}Ar$ $^{40}_{18}Ar$

(a) State the term used to describe these different types of argon atom. 1

isomer

(b) Explain why the mass number of each type of atom is different. 1

because ~~the~~ each isomer has a different number of neutrons.

(c) This sample of argon has an average atomic mass of 36·2.

State the mass number of the most common type of atom in the sample of argon. 1

36

[Turn over

MARKS

2. Read the passage below and attempt the questions that follow.

Hydrogen Storage

The portable storage of hydrogen (H_2) is key to the development of hydrogen fuel cell cars. While many chemists focus their attention on the use of metal alloys and hydrides for storing hydrogen, others have investigated the potential use of carbon nanotubes.

A carbon nanotube is a tiny rolled up sheet of graphite. A research team has designed a pillared structure made up of vertical columns of carbon nanotubes which stabilise parallel graphene sheets. Graphene sheets are layers of carbon which are one atom thick.

Lithium atoms are added to the pillared structure to increase the hydrogen storage capacity. Researchers claim that one litre of the structure can store 41 g of hydrogen, which comes close to the US Department of Energy's target of 45 g.

Adapted from *InfoChem Magazine* (RSC), Nov 2008

(a) Name the term used to describe a tiny rolled up sheet of graphite. 1

a carbon ~~[illegible]~~ nanotube

(b) Name the metal added to the pillared structure to increase the hydrogen storage capacity. 1

Lithium

(c) Calculate the number of moles of hydrogen that, researchers claim, can be stored by one litre of this structure. 2

Show your working clearly.

$n = \frac{m}{GFM}$ $n = \frac{0.041}{1}$

41 ÷ 1000 = 0.041

1 × 1 = 1

n = 0.041

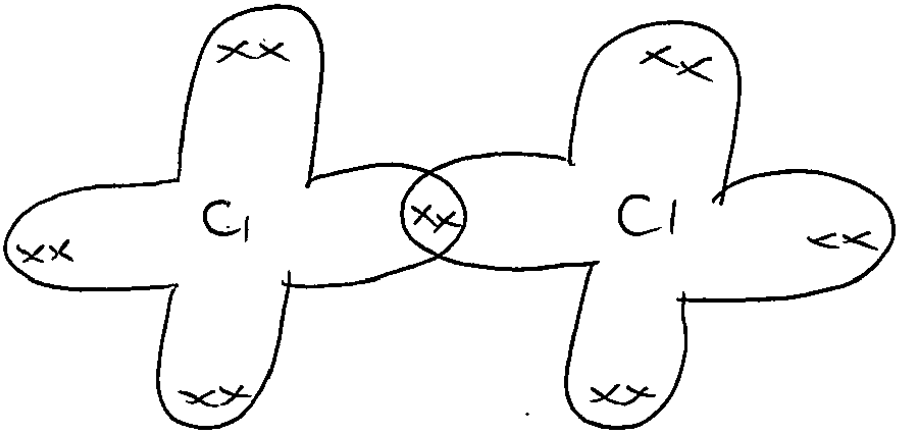
n = 0.041 moles of hydrogen.

MARKS

3. Chlorine can form covalent and ionic bonds.

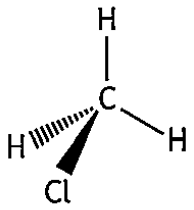
(a) Chlorine gas is made up of diatomic molecules.

Draw a diagram, showing all outer electrons, to represent a molecule of chlorine, Cl_2. 1



(b) Chloromethane is a covalent gas with a faint sweet odour.

The structure of a chloromethane molecule is shown.



State the name used to describe the shape of a molecule of chloromethane. 1

pyramidal

MARKS

3. (continued)

(c) When chlorine reacts with sodium the ionic compound sodium chloride is formed.

A chloride ion has a stable electron arrangement.

Describe how a chlorine atom achieves this stable electron arrangement. 1

there are even numbers of electrons on each energy level

(d) Covalent and ionic compounds have different physical properties.

Complete the table by circling the words which correctly describe the properties of the two compounds. 2

Compound	*Melting point*	*Conductor of electricity*
chloromethane gas	high / (low)	yes / (no)
solid sodium chloride	(high) / low	(yes) / no

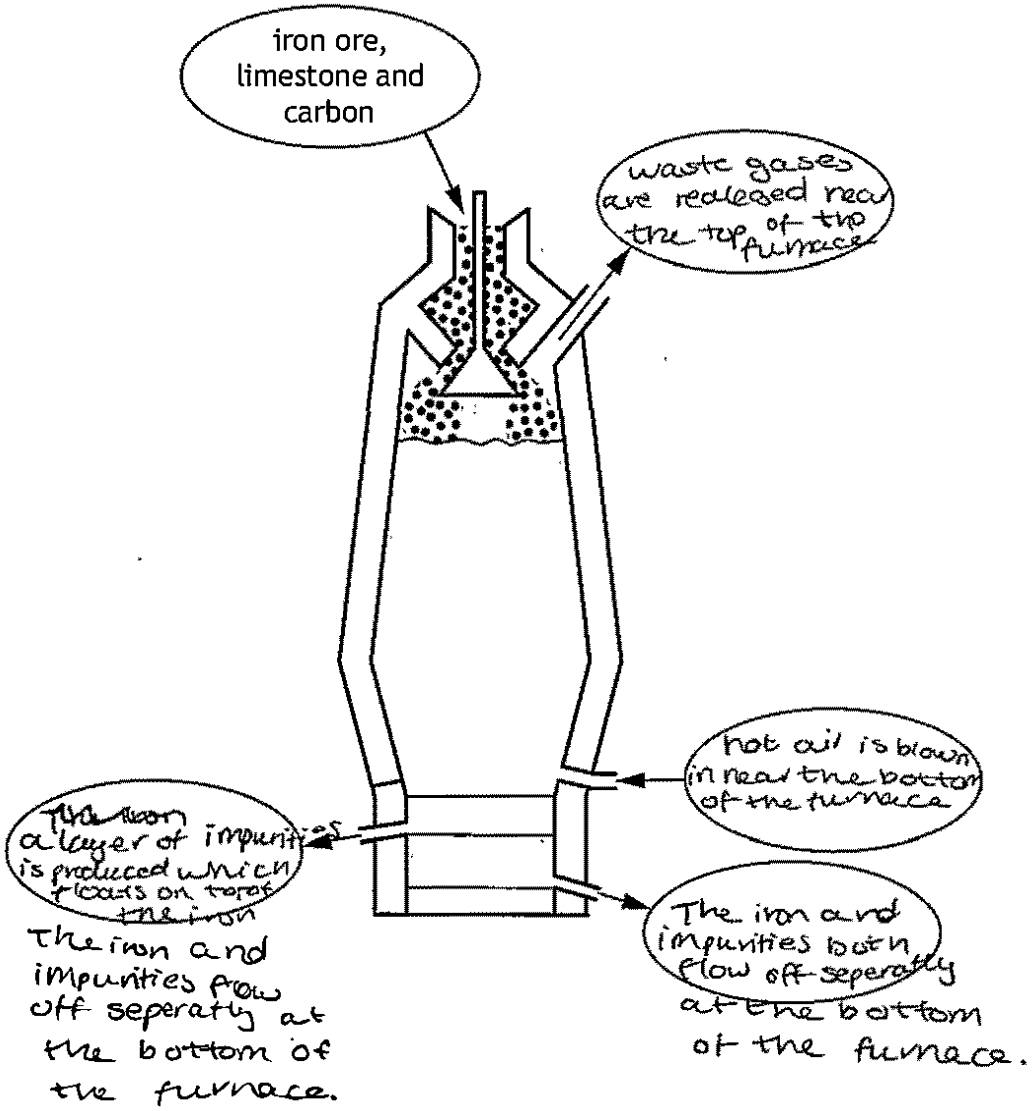
[Turn over

MARKS

4. Iron is produced from iron ore in a blast furnace.

(a) Iron ore, limestone and carbon are added at the top of the blast furnace. Hot air is blown in near the bottom of the furnace and, through a series of chemical reactions, iron is produced. Waste gases are released near the top of the furnace. A layer of impurities is also produced which floats on top of the iron. The iron and impurities both flow off separately at the bottom of the furnace.

(i) Use this information to complete the diagram. 2



MARKS

4. (a) (continued)

(ii) Explain why the temperature at the bottom of the blast furnace should not drop below 1538 °C. 1

You may wish to use the data booklet to help you.

because otherwise the iron will melt.

(b) Rusting occurs when iron is exposed to air and water.

During rusting, iron initially loses two electrons to form iron(II) ions. These ions are further oxidised to form iron(III) ions.

Write an ion-electron equation to show iron(II) ions forming iron(III) ions. 1

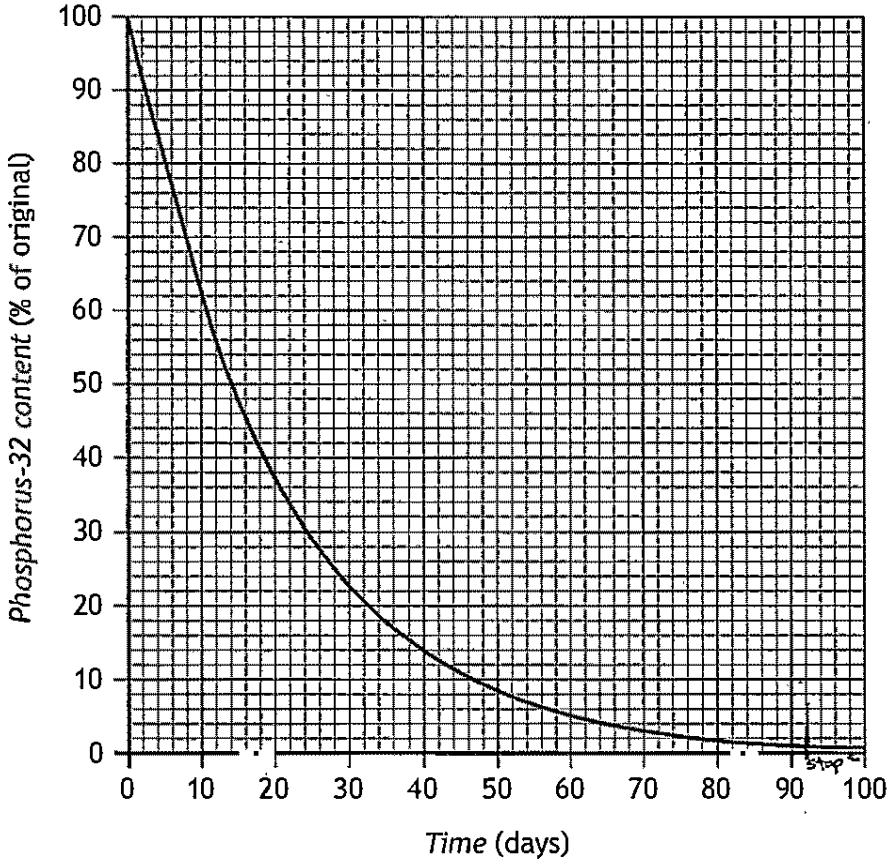
You may wish to use the data booklet to help you.

$Fe_{(II)}(s) \longrightarrow Fe^{2+}_{(III)}(aq) + 2e^-$

[Turn over

5. Phosphorus-32 is a radioisotope used in the detection of cancerous tumours. **MARKS**

(a) The graph shows how the percentage of phosphorus-32 in a sample changes over a period of time.



(i) Using the graph, calculate the half-life, in days, of phosphorus-32. **1**

100 → 50 → 25 → 12.5 → 6.25 → 3.125

1 2 3 4 5 6

1.5625

6 half lifes.

(ii) Using your answer to part (a) (i), calculate the time, in days, it would take for the mass of a 20 g sample of the radioisotope to decrease to 2·5 g. **2**

$\text{rate} = \frac{\Delta \text{quantity}}{\Delta \text{time}}$

$2.5 = \frac{20}{x}$

$2.5x = 20$

$x = \frac{20}{2.5}$

$x = 8$ days.

(b) Phosphorus-32 decays by emitting radiation.

During this decay the atomic number increases by 1.

Name the type of radiation emitted when phosphorus-32 decays. **1**

β beta

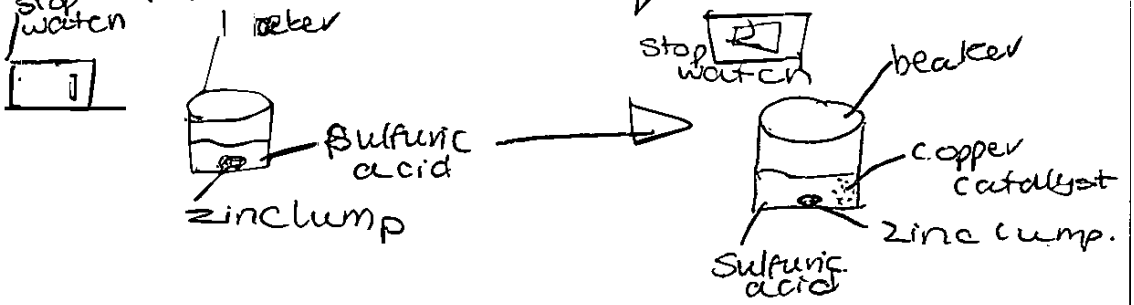
MARKS

6. A student wanted to investigate whether copper could be used as a catalyst for the reaction between zinc and sulfuric acid.

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

Using your knowledge of chemistry, suggest how the student could investigate this. 3

The student could set up an experement with zinc and sulfuric acid. he could put a lump of zinc in the acid and time how long it takes for the reaction to occur. He could repeat that a few times to make sure it's accurate. He could then put the copper in as a catalyst and repeate the experement, (keeping all variables the same) and then time it to see if the reaction was quicker or not.



The student could also try it with zinc powder and see if the reaction is any quicker, however, the student must remember that with powder the reaction will be quicker anyway as in powder the structure has been broken up and therefore the reaction is quicker.

[Turn over

MARKS

7. Carboxylic acids can be used in household cleaning products.

(a) Name the functional group found in all carboxylic acids. 1

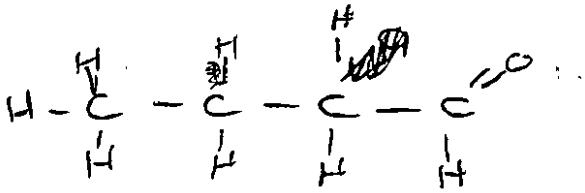
carboxyl

(b) Carboxylic acids have a range of physical and chemical properties. Melting point is an example of a physical property.

The table gives information about propanoic acid and butanoic acid.

Carboxylic acid	*Melting point* (°C)
propanoic acid	–21
butanoic acid	–5

(i) Draw a structural formula for butanoic acid. 1

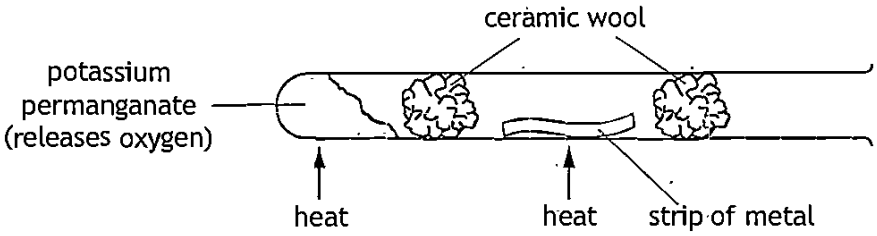


(ii) Explain why butanoic acid has a higher melting point than propanoic acid. 2

because in propanoic acid there are less carbons to break up.

MARKS

8. A teacher demonstrated the following experiment.



The results are shown in the table.

Metal	*Observation*
zinc	glowed brightly
copper	dull red glow
silver	no reaction

(a) (i) Describe what would be observed if the experiment was repeated using magnesium. 1

there would be a very bright light.

(ii) The teacher repeated the experiment using copper powder.

State the effect this would have on the rate of the reaction between copper and oxygen. 1

the rate of reaction would be quicker.

(b) Magnesium also reacts with steam to produce magnesium oxide and hydrogen gas.

$$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$$

Identify the substance which is being oxidised. 1

magnesium

[Turn over

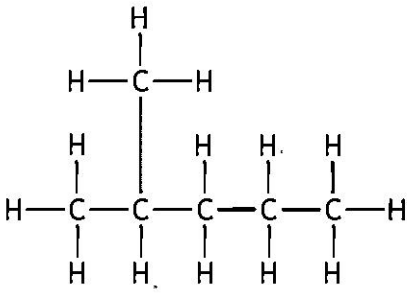
MARK

9. The alkanes are a homologous series of saturated hydrocarbons.

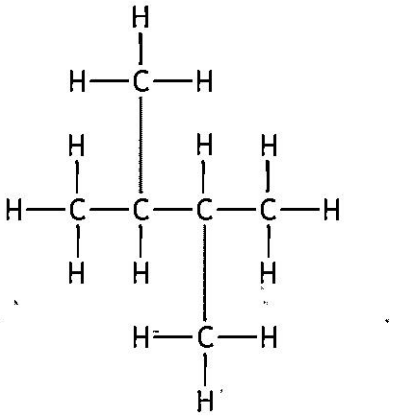
(a) State what is meant by the term homologous series. 1

a family of compounds with the same general formula ~~and~~ and similar chemical properties.

(b) The structural formula of two alkanes is shown.



2-methylpentane



2,3-dimethylbutane

State the term used to describe a pair of alkanes such as 2-methylpentane and 2,3-dimethylbutane. 1

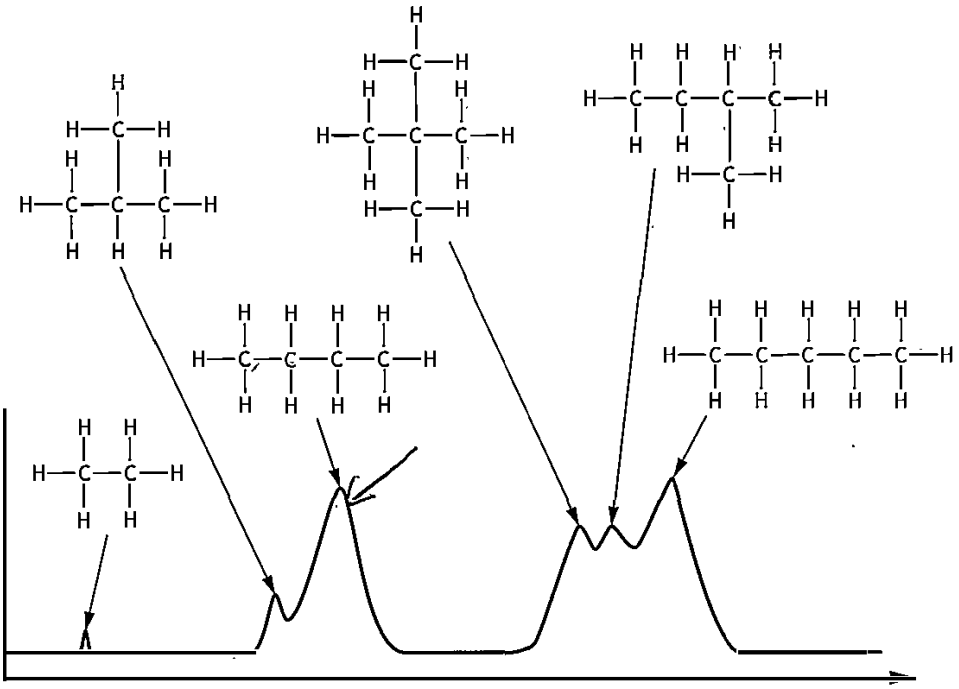
isomer

isotope.

9. (continued) MARKS

(c) The alkanes present in a mixture were separated using a technique known as HPLC. The mixture was vaporised and then passed through a special column. Different alkanes take different amounts of time to pass through the column.

The results are shown.



Time taken to pass through the column

(i) Write a general statement linking the structure of the alkane to the length of time taken to pass through the column. 1

the longer the time taken, the more carbons in the structure.

(ii) Propane was added to the mixture and the HPLC technique was repeated.

Draw an arrow on the graph to show the expected time taken for propane to pass through the column. 1

(An additional diagram, if required, can be found on *Page 27*.)

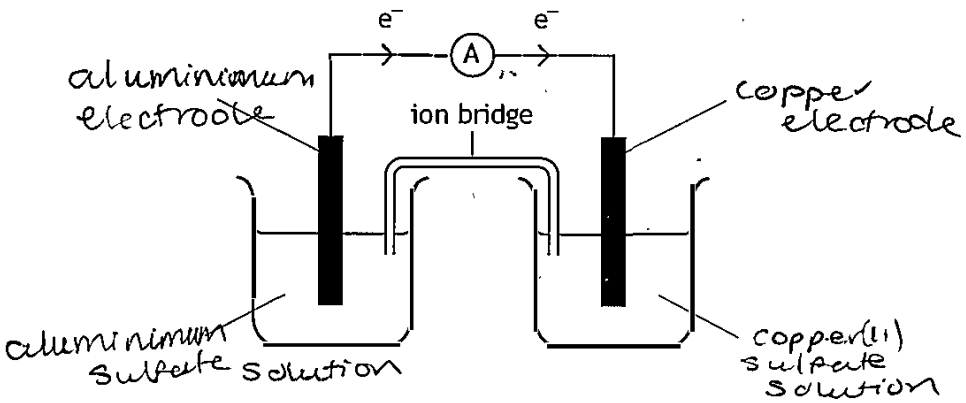
MARKS

10. A student set up an electrochemical cell using aluminium and copper electrodes as well as aluminium sulfate solution and copper(II) sulfate solution.

(a) (i) Complete the labels on the diagram to show the electrochemical cell which would give the direction of electron flow indicated. 1

You may wish to use the data booklet to help you.

(An additional diagram, if required, can be found on *Page 27.*)



(ii) The two reactions which take place in the cell are

$$Al(s) \longrightarrow Al^{3+}(aq) + 3e^-$$
$$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$$

Write the redox equation for the overall reaction. 1

$\times 2$ $2Al(s) \longrightarrow Al^{3+}(aq) + 3e^-$

$\times 3$ $3Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$

$2Al(s) \longrightarrow (Al^{3+})_2 + 6e^-$

$(3Cu^{2+})_3(aq) + 6e^- \longrightarrow 2Cu(s)$

$2Al(s) + (3Cu^{2+})_3 \longrightarrow (Al^{3+})_2 + 2Cu(s)$

(b) Calculate the percentage by mass of aluminium in aluminium sulfate, $Al_2(SO_4)_3$. 3

Show your working clearly.

$Al_2(SO_4)_3$

$3 \times 32 = 96$ S

$2 \times 27 = 54$ Al

$12 \times 16 = 192$ O

342

$$\% \text{ mass} = \frac{54}{342} \times 100$$

$= 15.789...$

$= 15.7\%$

MARKS

11. Sulfur dioxide is an important industrial chemical.

Sulfur dioxide dissolves in water to produce sulfurous acid.

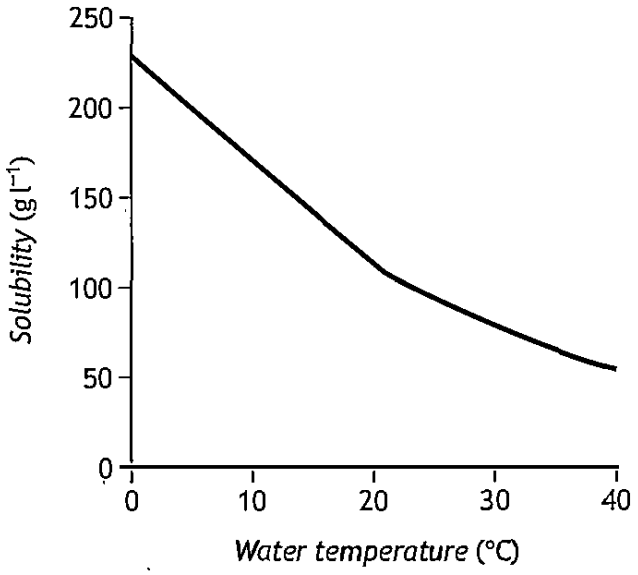
$$SO_2(g) + H_2O(\ell) \longrightarrow H_2SO_3(aq)$$

(a) Explain the change in the pH of the solution as sulfur dioxide dissolves. **2**

the pH of the solution drops to ~~>7~~ to being <7 as the water neutrilises the sulfur dioxide

additional space.

(b) The graph shows the solubility of sulfur dioxide at different temperatures.

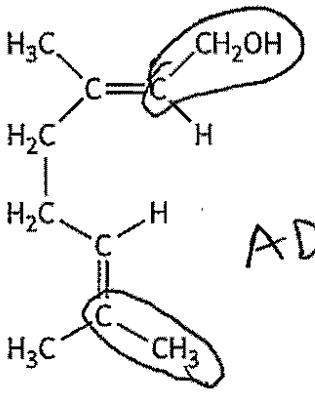


Describe the general trend in solubility as the temperature of the water increases. **1**

The solubility decreases as the water temperature increases.

MARKS

12. Geraniol is an essential oil known to have anti-inflammatory properties. A structure for the geraniol molecule is shown.



ADDITIONAL PAPER!

(a) Circle a functional group found in the geraniol molecule. **1**

(An additional diagram, if required, can be found on *Page 28.*)

MARKS

12. (continued)

(b) One of the compounds used to flavour foods is geranyl propanoate.

Name the family to which geranyl propanoate belongs. 1

carboxlic

RCOOR carboxly

(c) A student prepared a sample of geranyl propanoate from geraniol and propanoic acid.

geraniol	+	propanoic acid	⟶	geranyl propanoate	+	water
$C_{10}H_{18}O$	+	$C_3H_6O_2$	⟶	$C_{13}H_{22}O_2$	+	H_2O

15·4 g of geraniol was reacted with excess propanoic acid.

Calculate the mass, in grams, of geranyl propanoate which would be produced. 3

Show your working clearly.

15·4 ÷1000
= 0·0154

$m = n \times GFM$

$m = 0{\cdot}0154 \times 210$

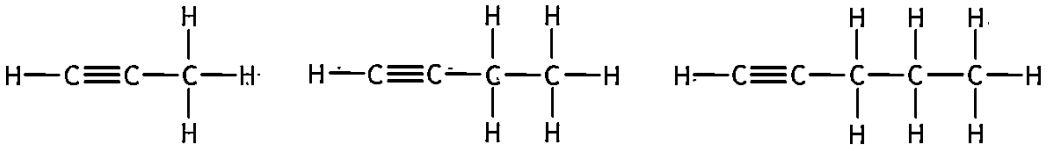
$m = 3{\cdot}234\ g$

$C_{13}H_{22}O_2$
- O_2 → 2×16
- H_{22} → 22×1
- C_{13} → 13×12

210

MARKS

13. The alkynes are a family of hydrocarbons which contain a carbon to carbon triple bond. Three members of this family are shown.

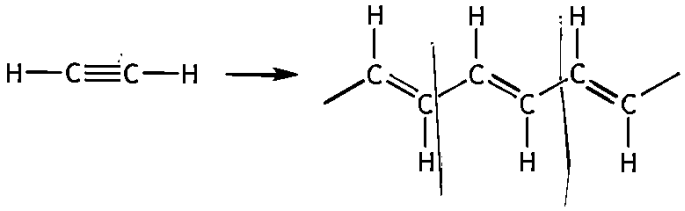


propyne but-1-yne pent-1-yne

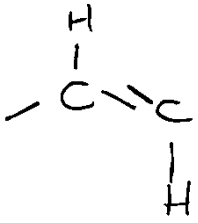
(a) Suggest a general formula for the alkyne family. 1

$C_{n+3}H_2$

(b) Ethyne can undergo polymerisation to form poly(ethyne).



(i) Draw the repeating unit in the polymer poly(ethyne). 1

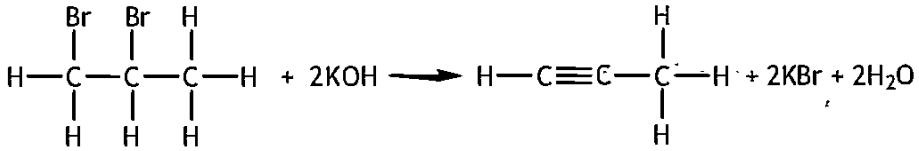


(ii) Name the type of polymerisation taking place when ethyne is converted to poly(ethyne). 1

addition polymerisation

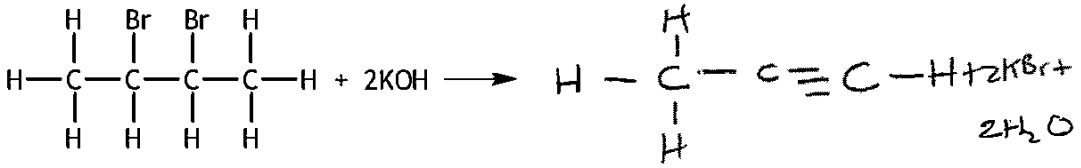
13. (continued) MARKS

(c) Alkynes can be prepared by reacting a dibromoalkane with potassium hydroxide solution.



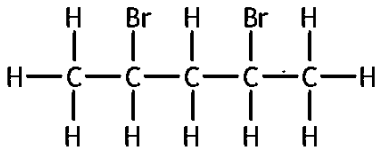
1,2-dibromopropane propyne

(i) Draw the **full** structural formula for the alkyne formed when 2,3-dibromobutane reacts with potassium hydroxide. 1



2,3-dibromobutane

(ii) The structure for 2,4-dibromopentane is shown below.



2,4-dibromopentane

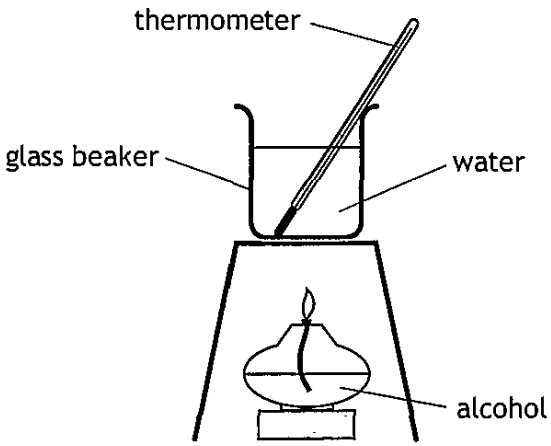
Suggest a reason why 2,4-dibromopentane does **not** form an alkyne when it is added to potassium hydroxide solution. 1

because the potassium hydroxide solution breaks the triple bond and therefor cannot be members of the family

[Turn over

MARKS

14. (a) A group of students carried out an experiment to measure the energy produced when 5 g samples of different alcohols were burned.

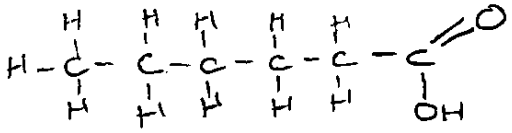


The results are shown.

Alcohol	*Energy released* (kJ)
propan-1-ol	158
butan-1-ol	170
pentan-1-ol	179
hexan-1-ol	185

182

(i) Draw a structural formula for hexan-1-ol. 1



(ii) Predict the energy released, in kJ, if the same mass of heptan-1-ol was burned. 1

182 kJ

MARKS

14. (continued)

(b) The energy released when an alcohol burns can be used to heat liquids other than water.

The data below was collected when the energy released, by burning an alcohol, was used to heat a sodium chloride solution.

Energy released when the alcohol was burned (kJ)	13·3
Initial temperature of sodium chloride solution (°C)	15
Final temperature of sodium chloride solution (°C)	49
Mass of sodium chloride solution heated (g)	100

Calculate the specific heat capacity, in $kJkg^{-1}°C^{-1}$, of the sodium chloride solution. 3

You may wish to use the data booklet to help you.

Show your working clearly.

$E_h = cm\Delta T$ $49-15=34$

$E_h = 4{\cdot}18 \times 13{\cdot}3 \times 34$

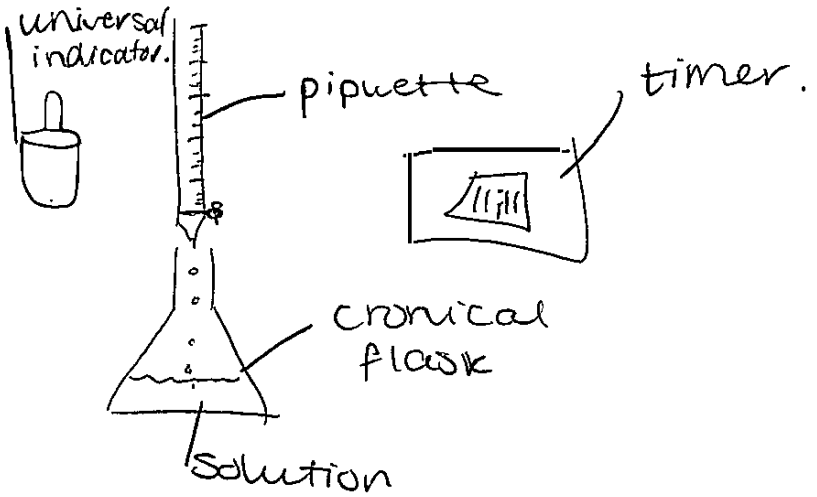
$E_h = 1890{\cdot}196\ KJ\ kg^{-1}\ °C^{-1}$

MARK

15. A student was given two solutions of sodium carbonate, one solution with a concentration of 0·1 mol l^{-1} and the other with a concentration of 0·2 mol l^{-1}.

Using your knowledge of chemistry, suggest how the student could distinguish between the solutions. 3

The student could do a titration experement with both the solutions and the one that changes quickest is the 0·1 mol^{-1}.

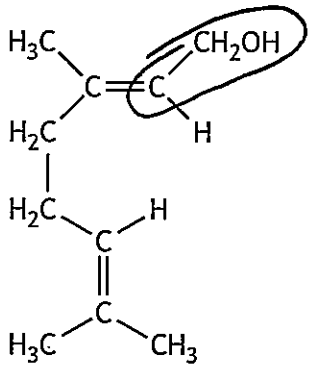


[END OF QUESTION PAPER]

MARKS

ADDITIONAL SPACE FOR ANSWERS

Additional diagram for Question 12 (a)



MARKS

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

11a.) The pH stays the same as when water is added, nothing will happen as its neutral and is neither acidic or alkaline.